

4.0 GROUNDWATER SUPPLY DEVELOPMENT AND THE SOURCE APPROVAL PROCESS

The development of a public groundwater resource in Massachusetts is governed by the Source Approval process. Regulations governing this process are set forth in the Groundwater Supplies section of the Massachusetts Drinking Water Regulations (310 CMR 22.21). The process is a step-by-step exploratory and development procedure that culminates in DEP approval of a public water system. The process differs for wells with *planned yields less than 100,000 gpd* and wells with *planned yields 100,000 gpd and greater*. The process also differs for wells constructed in bedrock or confined aquifers versus wells constructed in unconfined sand and gravel aquifers.

Prior to commencement of the development of a new public source, the proponent should conduct a thorough analysis of system demand and have a viable water conservation program in place. Conservation should include the full range of water supply conservation, demand management, and water reuse activities and devices. Water conservation is considered to be an integral part of the Water Management Act (WMA) Program, and additional information about water conservation and WMA requirements can be found in Section 10.0 of this document.

Impacts to natural resources are evaluated throughout the water supply development process. Through the Source Approval process, in conjunction with the WMA Withdrawal Permit application process, applicants are required to provide detailed information regarding potential withdrawal impacts. DEP coordinates WMA Withdrawal Permit application reviews with Source Approval reviews and solicits comments and recommendations from other state environmental agencies.

This section begins with a synopsis of the requirements for new source approvals. A more detailed explanation of these requirements can be found in the individual sections for wells supplied by a specific type of aquifer: unconfined, confined, or bedrock.

Section 4.0 also addresses requirements for obtaining source approval for springs as public water supplies, the delineation of aquifer protection zones, zoning and non-zoning controls for aquifer protection, well abandonment and decommissioning procedures, and requirements by other state and federal agencies for source development.

Some activities in the source development process and the delineation of Zone IIs will require a permit. For a list of activities, the proponent is referred to 310 CMR 4.00. Assistance can also be obtained from the DEP Infoline (1-800-462-0444) or the Regional Service Center located in each DEP Regional Office.

I. TO WHOM THE SOURCE APPROVAL PROCESS APPLIES

The Source Approval process shall be applied by DEP when considering the following:

1. A new public supply well.

2. An increase in the approved yield of an existing public supply source.
3. The reactivation of a public supply that has been off-line per order of DEP.
4. The reactivation of a public supply not in use for the last 5 years.
5. An approved source that was not developed and used within 5 years of the date of approval and for which the Zone I is not owned or controlled and wellhead protection requirements have not been met. For sources meeting the Zone I and bylaw requirements, additional testing or other work may be required by the DEP Regional Office before the source can be brought on-line.

The level of effort required to satisfy the Source Approval requirements for Numbers 2 through 5 will depend on the quality and applicability of existing hydrogeologic data and shall be left to the discretion of the Drinking Water Program in the Regional Office.

II. REPLACEMENT WELLS

Replacement wells are sources located in unconsolidated deposits no farther than 50 feet from the wells they are replacing. They shall not significantly alter the local groundwater hydraulics or Zone II boundaries. Proposals for replacement wells shall be submitted to DEP for approval. Replacement wells will generally be exempt from certain source approval requirements at the discretion of the Drinking Water Program in the Regional Office.

4.1 SYNOPSIS OF THE SOURCE APPROVAL PROCESS FOR ALL PUBLIC SUPPLY WELLS

The following section outlines the major components of the source approval process for *all public supply wells*. An in-depth description of the technical requirements for each step of the Source Approval process is described in subsequent sections for the specific type of aquifer supplying the well. DEP-approved well yields are expressed in gallons per day (gpd).

Step 1: Explore Potential Sources of Groundwater

If, during the exploratory phase of the Source Approval process, contaminants listed in the Massachusetts drinking water standards are discovered in the test well, the sequence of the Source Approval process will be altered. Pumping and redevelopment of the test well, followed by resampling using sanitary sampling protocols, will be required. If contaminants are still present, alternative sources should be considered.

The concentrations of contaminants found and the availability of alternative sources will determine whether the old site should be abandoned and/or referred to DEP's Bureau of Waste Site Cleanup (BWSC) for investigation. If alternative sources are not an option,

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your Drinking Water Program Point of Contact will contact DEP's Office of Research and Standards (ORS) and request an evaluation of the health effects of the detected chemicals to determine the necessary treatment.

If treatment is necessary, the following must be performed:

1. Design and conduct a pumping test
2. Conduct standard pumping test water quality sampling
3. Review of water quality results by ORS
4. Design and construct wellhead treatment facility
5. Design and implement raw water monitoring program to assure early warning of dramatic changes in raw water quality that may adversely impact treatment
6. Refer site to BWSC for investigation of contaminant source

It is imperative that water suppliers communicate with the Drinking Water Program at the DEP Regional Office when contaminants are discovered in exploratory wells.

Step 2: Request Site Exam

The proponent must submit a request for a site exam to the Drinking Water Program at the Regional Office. This request must be accompanied by three (3) copies of the following documents:

1. Location and log (depth, yield, lithology) of all exploratory wells
2. Results of field test, secondary contaminant, and volatile organic compound (VOC) analyses
3. A characterization of land use within the required radius around the well including:
 - a. 1:6000 scale or larger map depicting the proposed well site and the area located within a 1/2 mile radius of the proposed well
 - (1) Current land uses
 - (2) Approved water withdrawals, registered or permitted by DEP as well as any private withdrawals within a 1/2 mile radius of the well. The approach used to determine the presence or absence of private wells shall be discussed in the submittal. DEP recommends the assumption be made that homes not supplied by public water as shown on water supply distribution

maps are dependent on private sources.

(3) Zoning

(4) Existing and potential sources of contamination, including any landfills and hazardous waste sites located within a 1/2 mile radius of the well. Hazardous waste sites shall be considered to be any locations listed in the most current BWSC *List of Confirmed Disposal Sites and Locations to Be Investigated*. For an updated list of sites, contact the Regional Service Center at your DEP Regional Office.

(5) Great ponds, streams, and wetlands within a 1,000 foot radius of the well

b. Discussion/evaluation of potential impacts of existing and potential sources of contamination to the new water supply

c. For test wells installed at potential production well sites:

(1) Water quality analysis results

(2) Estimate of well yield

(3) Well log and as-built construction diagram

4. For wells with planned yields 100,000 gpd and greater, the following also apply:

a. Preliminary conceptual model of the aquifer, including:

(1) Stratigraphic cross-sections, boundary conditions, etc. (see Section 4.3, *Delineation of Wellhead Protection Zones*)

(2) Initial estimate of Zone II or Zone III (see Section 4.3)

b. Location and type of potential sources of contamination in the preliminary Zone II.

c. Surveyed site plan depicting Zone I, including all well locations and elevations.

d. Water use projections based on a community's forecasted demand for a 20-year planning period. These projections may be acquired from the Department of Environmental Management's Office of Water Resources (OWR). The forecasts are based on projected demographic changes provided by regional planning agencies and on water use data provided by OWR.

e. A detailed description of a community's efforts to discover and minimize unaccounted-for water. This should include a summation of historical and current efforts at leak detection and metering, as well as a narrative describing the current unaccounted-for percentage and the attempts being made to lower

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that percentage, if necessary. Schedules for calibrating master meters should be included.

- f. Outline of the community's strategy for adopting and implementing local control measures meeting 310 CMR 22.21. (See Section 4.6, *Wellhead Protection Zoning and Non-Zoning Controls*.) Relevant existing and proposed local control measures should also be submitted.

Step 3: Conduct Site Exam

The site exam is conducted by DEP's regional source approval staff, the water supplier, and the consultant. It includes a land use/sanitary survey of the preliminary Zone II and a review of proposed observation well locations for the pumping test. Special conditions for pumping test design and performance are also discussed. The status of Zone I ownership or control should be discussed.

Step 4: Assess Viability (for new small systems only)

New small community and specified nontransient noncommunity systems (NTNCs) serving less than 1,000 people must undergo a viability assessment. Refer to Flow Diagram in Appendix B-1. All other systems should move directly to Step 5.

DEP uses this procedure to determine whether an applicant has adequately identified the resources necessary to ensure compliance with the SDWA. This procedure also describes how DEP will assist the applicant to adequately determine its resource needs.

1. Public education, outreach, and training will be the primary means for controlling the creation of new nonviable small public water systems as identified in Appendix B-2. Proposed small systems would be provided informational brochures on Safe Drinking Water Act compliance/cost requirements at the time they request initial information about DEP source approval and permitting requirements.
2. Each small community public water system and specified NTNC applicant who applies to site a source and conduct pumping tests for sources under 70 gallons per minute will complete the following:
 - a. DEP Transmittal Form for Application and Payment
 - b. Permit application for BRP WS 13, *Approval to Site a Source and Conduct Pumping Tests for Sources Under 70 Gallons per Minute* [BRP WS 06-31, Application for Permit or Approval]
 - c. DEP Viability Assessment Forms (Appendices B-3 and B-4) for assessing the small system's technical, managerial, and financial capacity.

During the first stage, the DEP Regional Office will refer the applicant to an appropriate "Mobilization Partner" for technical assistance to discuss and resolve various issues related to water supply and financial planning. Publicly owned systems may contact RHI's Rural Community Assistance Program (508-297-5300) for help filling out the forms. Privately owned systems may contact the Massachusetts Department of Public Utilities (617-727-3597) for help.

3. DEP will forward all viability assessment forms to the Mobilization Partner.
4. The Mobilization Partner will consider the following items when determining viability and when making viability assessment and assurance recommendations:
 - a. Determine if the system has investigated other sources of water
 - b. Determine small systems viability based on the following criteria:
 - (1) Demonstration that the system plans to have access to two years of funding
 - (2) Commitment that the applicant plans to provide funding and other necessary resources to meet current and future SDWA compliance.
 - (3) Demonstration that the applicant plans to have access to emergency funds to cover unforeseen expenses. Demonstration of this requirement would include the following financial instruments: escrow account, common stock issue, and a long-term debt issue, or short-term debt of six years on a demand note basis for the purpose of covering unforeseen costs.

Note: Demand notes do not require Department of Public Utilities (DPU) approval. A line of credit will not be considered as a demonstration of availability of funds.
 - c. The Mobilization Partner will provide DEP with a viability assessment - with or without recommendations for follow up.
 - d. DEP staff will incorporate its viability assessment and assurance comments into the pumping test approval letter and will continue the new source approval process according to DEP guidelines.

Step 5: Submit Pumping Test Proposal

The proponent must submit a pumping test proposal to the Department in accordance with these Guidelines. The primary objective of the pumping test is to resolve questions concerning safe yield and existing/potential water quality. At the Department's discretion, the objectives may be expanded.

1. The proposal must include, at a minimum:

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- a. Planned pumping rate
 - b. Planned duration of test
 - c. Location of discharge point
 - d. Plan showing location of observation wells, if applicable
 - e. Frequency of reading observation wells, if applicable
 - f. Types of samples to be collected and the name of the Massachusetts or EPA certified laboratory to be employed for all water quality testing required by the Source Approval process
 - g. Frequency and locations of sampling for water quality
 - h. Required permits, registrations or notices, such as state (*e.g.*, Water Management Program, Wetlands) and local (*e.g.*, Conservation Commission)
2. *For wells with planned yields of 100,000 gpd and greater*, the proposal must also include the following:
- a. Discussion of monitoring well locations, peat probing, or a combination of both, specifically sited to define the stratigraphy in the wetland closest to the pumping well.
 - b. Discussion of methods for delineating Zone II or Zone III (see Section 4.3).
 - c. Discussion of zoning/non-zoning controls
 - (1) Draft, existing, or proposed control measures (including overlay district map) meeting the requirements of 310 CMR 22.21(2) and a proposed schedule for adopting these controls, or
 - (2) For non-municipal water systems, a schedule for meeting "best effort" criteria, as described in Section 4.6.
3. The pumping test proposal must, at a minimum, address the following:
- a. Duration/Stabilization
 - (1) *Wells with planned yields less than 100,000 gpd:*
 - *unconfined:* the pumping test shall be conducted for a minimum of 48 hours. If stabilization has not been reached during this period, the test

will be continued until stable conditions have been reached. (See Section 4.2.1.VI.D.)

- *confined*: a 2-day or 10-day pumping test shall be conducted depending on stabilization criteria used. (See Section 4.2.2.VII.D.)
- *bedrock*: the pumping test shall be conducted for a minimum of 48 hours at the pumping rate determined by the step-drawdown test. (See Section 4.2.3.VII.D.)

(2) *Wells with planned yields 100,000 gpd and greater:*

- *unconfined*: the prolonged pumping test shall be conducted for a minimum of 5 days. The duration of the pumping test shall be lengthened if the drawdown has not stabilized or if water quality is questionable or changing. (See Section 4.2.1.VI.D.)
- *confined*: a 5-day or 10-day pumping test shall be conducted depending on stabilization criteria used. (See Section 4.2.2.VII.D.)
- *bedrock*: the pumping test shall be conducted a minimum of 10 days at a pumping rate determined by the step-drawdown test. (See Section 4.2.3.VII.D.)

b. Observation/Monitoring Wells

(1) *Wells with planned yields less than 100,000 gpd*: In general, no observation/monitoring wells will be required. However, in circumstances where special water quality or quantity issues prevail, observation/ monitoring wells may be required by the Department.

(2) *Wells with planned yields 100,000 gpd and greater:*

- *unconfined*: the number and location of observation wells depends on geologic/hydrogeologic conditions encountered on a site by site basis.
- *confined*: a minimum of five observation wells are required -one (1) well in the confining layer, one well in the unconfined aquifer and three wells in the confined aquifer.
- *bedrock*: no observations wells are required unless additional information is required to evaluate the longevity and integrity of the production well.

c. Discharge Line

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The discharge line location must be specified and located so as to eliminate recirculation of pumped water.

d. Drawdown Readings

(1) *Wells with planned yields less than 100,000 gpd:*

- *unconfined and confined:* readings shall be taken every minute for the first 10 minutes, every 10 minutes for the first hour and once per hour until shutdown.
- *bedrock:* water levels in the production well shall be measured every 5 minutes for the first 2 hours and once per hour thereafter.

(2) *Wells with planned yields 100,000 gpd and greater:*

- *unconfined and confined:* readings shall be taken at consistent intervals to include 10 data points for every log cycle beginning with 1 minute, 10 minutes, and 100 minutes, respectively, and twice daily thereafter until the termination of the pumping test, with the initial measurement recorded at $t = 0.5$ minute.
- *bedrock:* readings shall be taken every 5 minutes for the first 2 hours and once every 6 hours thereafter.

e. Recovery Readings

These readings should be taken at the same frequency as the drawdown readings; readings should continue for the same period as the pumping period or until the water level in the well recovers 95% of drawdown at stabilization, whichever occurs first.

f. Water Quality Analysis

The water quality sampling schedule and parameters to be investigated should be commensurate with required Water Quality Sampling and Testing, Appendix A (in accordance with 310 CMR 22.00) and requirements imposed by the amendments to the SDWA. DEP reserves the right to require additional testing and increase the list of parameters if site conditions warrant.

Step 6: Pumping Test Proposal Approved

Step 7: Conduct Pumping Test

This test must be conducted according to the *PWS Guidelines* and the approved

pumping test proposal.

Step 8: Shut Down Pumping Test

Recovery readings should be taken in accordance with these *PWS Guidelines* and the approved pumping test proposal. The pumping test may be shut down only after consultation with the DEP Regional Office, in order to assure that DEP agrees that stabilization has been achieved.

Step 9: Submit Source Final Report to DEP Regional Office

The proponent must submit a Source Final Report in accordance with the *PWS Guidelines*. Two copies of the report must be submitted for *wells with planned yields less than 100,000 gpd*. Three copies must be submitted for *wells with planned yields 100,000 gpd and greater*. The Source Final Report should include, at a minimum:

1. All data collected during the pumping test
2. Aquifer transmissivity and storativity including graphs and calculations, determined from the pumping test analysis
3. Safe yield calculations using appropriate methods (See Section 4.2.1.VII.)
4. Water quality analysis results should be presented and explained. If treatment is necessary, treatment options should be presented and discussed.
5. Latitude and longitude of new source
6. The pumping schedule that is anticipated for the new source based on population served and the engineering of the complete water system
7. A discussion of the wetlands hydraulic connection to the underlying aquifer based on the aforementioned borings and/or peat probes
8. A discussion of how the well's proposed pumping schedule will affect the drawdown and recovery of the water table proximal to the proposed source
9. All requirements contained in Sections 4.4, *Source Final Report*, and 4.6, *Wellhead Protection Zoning and Non-Zoning Controls*.

Step 10: Source Final Report Approved

Step 11: Submit Design Plan for Permanent Works to the DEP Regional Office

The water supplier must have demonstrated ownership or control of the Zone I by this

point.

Step 12: Permanent Works Installation Approved

Step 13: Notify DEP Regional Office When System is Complete

Any design modifications must be noted. In addition, the design plan must identify the owner and party responsible for the public water system. The responsible party must be a certified public water system operator, in accordance with 310 CMR 22.11B. Any changes in designee must be reported to the DEP Regional Office.

Step 14: Site Inspection of Permanent Works

DEP will inspect the site and collect a sample for water quality analysis after pumping to waste for 1 hour.

Certain hydrogeological, geological, or logistical situations may exist that cause the Department to require activities during the source approval process that may exceed the minimum requirements of the *PWS Guidelines*.

1. In certain complex hydrogeologic situations, it is difficult to predict the zone of contribution for a well without employing a numerical computer model. Based on the geologic and hydrogeologic complexity of the aquifer, DEP may require that a specific modelling approach be used to delineate the Zone II.
2. In situations with several independent wells pumping simultaneously, a numerical computer model may be necessary.
3. When water quality problems are known to exist proximal to or at a proposed public supply well, the need for water quality information obtained from a pumping test increases.
4. In the aforementioned situations, the Department may require:
 - a. The use of a numerical computer model
 - b. The installation of as many monitoring or observation wells as are necessary to validate the assumptions used in the computer model and to assess existing or suspected water quality problems
 - c. All of the wells within the same aquifer be pumped at their approved yield for the duration of the pumping test
 - d. The proposed well be pumped at the rate for which source approval is sought

- e. The duration of the pumping test exceed the minimum requirements of the *PWS Guidelines*
- f. Additional water quality parameters be examined or more frequent sampling be employed than is called for in the *PWS Guidelines*

It shall be left to the discretion of DEP to decide when listed supplemental activities are required.

- 5. To increase the yield of one well to equal the yield historically pumped by two existing wells within 400 feet of each other, the following conditions must be met:
 - a. A pumping test must be conducted on each and every well for which an increase is sought.
 - b. The pumping test must be conducted at the rate for which approval is sought.
 - c. The pumping test must be conducted in accordance with the *PWS Guidelines*. The pumping test requirements shall be discussed with the Drinking Water Program Point of Contact at the appropriate DEP Regional Office.
 - d. A conceptual Zone II delineation must be completed for the increased pumping rate.
 - e. Pumping test reporting requirements shall be discussed with the appropriate DEP Regional Office.

Step 15: Meet Requirements of the Surface Water Treatment Rule

The Surface Water Treatment Rule (SWTR), an amendment to the federal Safe Drinking Water Act, requires DEP to notify the U.S. Environmental Protection Agency (EPA) of groundwater sources determined to be under the direct influence of surface water and at risk for carrying waterborne diseases such as giardiasis. Water suppliers developing groundwater sources must demonstrate compliance with the SWTR by either receipt of a DEP SWTR exemption, institution of appropriate wellhead/watershed protection, or installation of adequate filtration. Exemptions are granted based upon well siting, well construction, or the results of microscopic particulate analysis (MPA).

- 1. *Sand and Gravel Wells* - New public supply wells that meet one of the following criteria will be granted DEP SWTR exemptions:
 - a. Groundwater sources located 150 feet or more horizontally from a surface water feature are exempt from MPA sampling. "Surface water feature" is defined as an area continuously inundated with flowing or standing water. Wetlands or low lying areas that are only periodically flooded are not

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considered surface water features.

- b. Groundwater wells constructed with a sanitary seal and the screens of which are separated from surface water features by a confining layer are exempt from MPA sampling. "Confining layer" is defined as a continuous aerially extensive geologic unit of low permeability.
- c. A groundwater source that cannot meet either of the exemption criteria listed above must meet all of the following to be exempt from MPA testing.
 - (1) The top of the well screen must be 50 feet or more below the ground surface.
 - (2) The well must be approved by DEP to pump 720,000 gpd on average or less.
 - (3) The well must have a properly installed sanitary seal.
 - (4) The well must not have any total or fecal coliform violations during the first three years of operation. Testing will be conducted twice annually (spring and fall) for bacteria. If there are no total or fecal coliform present over the three year period, the source will be considered to have met the exemption criteria and will not be required to conduct MPA testing or install filtration.

If a groundwater source cannot meet any of the above criteria, MPA testing must be conducted in the spring and fall of the first year the source is on line. Testing will be conducted between April 1 and May 30 and between August 15 and October 15. The initial MPA testing round may occur either in the spring or fall, whichever time period occurs first after the well has been on line for at least six months.

MPA results will be reviewed by DEP regional source approval staff, who will determine whether the source warrants a DEP SWTR exemption, requires additional testing, or requires filtration.

- 2. *Bedrock Wells* - Wells constructed in bedrock must be approved to pump 100,000 gpd or less and meet all the following criteria to be considered for an exemption:
 - a. The well must be 50 feet or more in depth.
 - b. The well must have a surface seal.
 - c. The well must be 200 feet or more from a surface water feature.

If all criteria are met, the water supplier will be required to test the source monthly for total coliform bacteria to remain in compliance with the SWTR. Bedrock

sources that fail to meet the above criteria must conduct MPA testing in the spring and fall in accordance with the schedule listed above for sand and gravel sources.

4.2 SOURCE APPROVAL COMPONENTS

This section describes the Source Approval process and the data requirements for each step of the process.

I. GROUNDWATER EXPLORATION FOR ALL WELLS

Due to the complex nature of bedrock fracture systems and the generally difficult task of determining the recharge area to a well constructed in bedrock, the Department requires that all viable unconsolidated aquifer deposits be considered prior to proposing development of a bedrock public supply well. It shall be left to the discretion of the DEP regional source approval staff to evaluate the applicability of this requirement.

Water suppliers contemplating development of a source should review all hydrogeologic information for the area being considered before undertaking costly subsurface explorations. This information includes USGS Hydrologic Atlases and Data Reports, USGS Surficial Geologic and Bedrock Geologic Quadrangle Maps, DEP Water Quality data, historical USGS water level data, consultant reports addressing the specific area, and reports on commercial, industrial, and private water supply uses. Specific sources of information are compiled in DEP's Massachusetts Hydrogeologic Information Matrix.

It is DEP's policy to accept hydrogeological reports submitted by engineers or geologists skilled in groundwater exploration or contaminant transport hydrogeology as the situation warrants the need for that skill. If the submittal includes plans for pump facilities and appurtenances related to a Source Approval or for the design of a treatment system for a contaminated water supply, the plans must be stamped by a Registered Professional Engineer.

II. REQUIRING USE OF REGISTERED WELL DRILLERS ONLY

DEP will not pay or reimburse payment of well drillers who are not registered in Massachusetts. Pursuant to 313 CMR 3.00, all well drillers doing business in the Commonwealth must be registered with the Department of Environmental Management.

Water suppliers contemplating groundwater exploration activities should contact the appropriate DEP Regional Office to discuss the Source Approval process.

Groundwater exploratory or development work in or near vegetated wetlands, or other environmentally sensitive areas, may require filing a Notice of Intent with the local Conservation Commission. The Commission should be contacted to determine if this will be necessary.

4.2 Source Approval Components

The process of implementing appropriate zoning and non-zoning controls prior to bringing a source on line *with planned yields 100,000 gpd or greater* should commence during the groundwater exploratory phase of the Source Approval process. (See Section 4.6.) It is recommended that the town add to the town meeting warrant an article or resolution describing the Source Approval process being entered into, the zoning and non-zoning control requirement, the importance of water resource protection, and a notice to the meeting that the passage and adoption of the appropriate controls will be voted on at the next annual town meeting. A public education/awareness campaign to assist in a favorable reception at the town meeting should commence at this time.

4.2.1 Source Approval Process for Unconfined Aquifer Wells

- I. GROUNDWATER EXPLORATION (as described in Section 4.2.I)
- II. REQUEST FOR SITE EXAM

The Request for Site Exam must contain a characterization of land use within a 1/2 mile radius around the well which includes:

- 1. A map showing:
 - a. Current land uses
 - b. Approved water withdrawals, registered or permitted by DEP, and any other private, commercial, or industrial wells
 - c. Zoning
 - d. Existing and potential sources of contamination
- 2. A discussion/evaluation of potential impacts of existing and potential sources of contamination to the new water supply
- 3. For test wells at potential production well sites, the following must be provided:
 - a. Water quality analysis results (See Section 4.2.1.IV.I.1, Exploratory Phase)
 - b. Estimate of well yield
 - c. Well log and as-built construction diagram

Requests for *wells with planned yields 100,000 gpd and greater* must also include:

- 1. Location of and geologic logs (depth, yield, lithology) for all exploratory wells
- 2. Preliminary conceptual model of the aquifer, including:
 - a. Stratigraphic cross-sections, boundary conditions, etc.
 - b. Initial estimate of the Zone II or Zone III area
- 3. Location and type of potential contamination sources in the preliminary Zone II

4. Estimate of potential production well yield based on initial pumping test conducted on a 2-1/2 inch test well
5. Water quality sample collected before the termination of the initial 2-hour pumping test. The sample must be analyzed for parameters discussed in Section 4.2.1.IV.I. Water suppliers shall contract a Massachusetts or EPA certified laboratory to conduct analyses on all water samples collected for the Source Approval process
6. Strategy for meeting wellhead protection requirements of 310 CMR 22.21(2). This will include, at a minimum:
 - a. Name, title, and phone numbers of lead local contacts who will be pursuing changes to zoning and/or health regulations, pursuing such protection with neighboring communities, and implementing controls that meet DEP requirements;
 - b. Timeframes for drafting any needed changes to bring local controls up to DEP requirements, for bringing regulatory changes to Planning Board, Board of Health, Town Meeting, etc., and a plan for public education that will ensure success in these forums;
 - c. Proposed schedule and contacts for ensuring protection of any part of the Zone II that extends into a neighboring community; and
 - d. Any relevant existing/proposed control measures.
7. A surveyed site plan including Zone I, well locations, and elevations

III. DEP SITE EXAM

A site exam shall include, but is not limited to:

1. Land use/sanitary survey of the entire preliminary Zone II by DEP regional staff, the water supplier, and the consultant
2. Discussion of special conditions for pumping test design and performance
3. Identification of any potentially hydrologically connected surface water features, including wetlands, and discussion of determining withdrawal impacts to them
4. Discussion of observation well locations to be used during the pumping test
5. The site generally will not be approved for further testing unless the following conditions can be satisfied:

4.2.1 Source Approval Process for Unconfined Aquifer Wells

- a. The site cannot be subject to a significant risk from floods or other disasters unless the finished wells can be properly protected.
- b. The site can be made readily accessible during all seasons of the year.
- c. The site is not unduly subject to short circuiting from a surface body of water.
- d. The site can meet Zone I requirements (see Section 4.3.1).
- e. The site cannot be located within 1/2 mile of potentially serious sources of pollution such as active or abandoned sanitary landfills, major fuel storage and/or transmission facilities, road salt stockpile areas, and hazardous substance storage areas, unless DEP has granted specific written approval. Approved sites are subject to such additional monitoring requirements as may be considered necessary by the Department.

In addition to the above requirements, all potentially harmful activities within the preliminary Zone II and Zone III must be identified. It is the responsibility of the proponent's consultant to alert DEP to the existence of such hazards. This information shall be shown on a USGS map at a scale of 1:6000 or larger and submitted as part of the Request for Site Exam.

- f. The Department must approve all test well sites prior to submittal of the pumping test proposal. Departmental approval will be in writing and normally shall be granted only after review of the groundwater exploration report (Request for Site Exam), subsequent sanitary survey of the test well site by an engineer from the Department, and, for *wells with planned yields 100,000 gpd and greater*, a review of water quality data.

Under special circumstances the Regional Engineer may verbally approve sites for further testing if the above requirements have been met and if a letter of approval will follow. Any substantial changes in site conditions will require re-evaluation.

IV. SUBMITTAL OF PUMPING TEST PROPOSAL

The following subsections discuss pumping test design requirements.

A. Planned Pumping Rate

1. Pumping tests of final production wells shall be conducted at the rate for which approval is sought.
2. Test wells shall be pumped at a minimum of 50% of the design rate for the production wells. A step drawdown test is recommended.

3. Water levels shall be allowed to recover between the step drawdown test and the prolonged pumping test.
4. The DEP Regional Office will be notified of any changes in the pumping rate.
5. The pumping rate must be recorded every 2 hours.

B. Observation Wells

All wells with planned yields 100,000 gpd and greater must have a completed Zone II delineation or adequately protected Zone III (see Section 4.3). The exact number and location of observation wells depends upon geologic/hydrogeologic conditions encountered on a site-by-site basis. In most cases, observation wells are not required for wells or wellfields with planned yields less than 100,000 gpd.

1. *Location* - Observation wells should be placed between the pumping well and any significant hydrogeologic boundaries such as no flow boundaries, constant flux boundaries or constant head boundaries. Additional wells may also be necessary to measure the effects of partial penetration.
 - a. Well placement should allow for the calculation of aquifer transmissivity by distance-drawdown and time-drawdown methods.
 - b. A plan of the proposed locations and frequency of measurement of all observation wells to be used for drawdown recordings and recovery recordings must be included in the pumping test design.
 - c. Elevations and locations of all observation wells must be surveyed to a USGS benchmark relative to mean sea level.
2. *Construction Details* - The depth, diameter, and screened interval must be provided for each observation well.
3. *Ambient Well* - To assist in determining stabilization, an additional observation well should be located outside the area of influence of the pumping well but within the same geologic formation. This well will be used to measure ambient conditions within the aquifer during the pumping test. Water level readings should commence 5 days prior to startup of the pumping test.
4. *Response Test* - The response to changing water levels should be tested for all wells to be used as observation wells by either injecting or removing a known volume of water into or out of each well and measuring the subsequent rise or decline of the water level. The initial rise of water should be dissipated within a few minutes (to within about 0.01 feet of the initial level).

4.2.1 Source Approval Process for Unconfined Aquifer Wells

5. *Quality Control* - Quality control measures which ensure that no contamination is introduced into the aquifer must be employed during the drilling and installation of the observation wells. Any observation well permanently abandoned subsequent to completion of the pumping test should be filled in such a manner that vertical movement of water within the well bore, including movement within the annular space surrounding the well casing, is effectively and permanently prevented, and the water is permanently confined to the specific zone in which it originally occurred. (See Section 4.14, *Well Abandonment and Decommissioning*.)

C. Induced Infiltration

For wells located near a surface water body, the amount of induced infiltration caused by pumping the well must be evaluated. The amount of induced infiltration will affect the size and shape of the Zone II, and may affect water quality at the well site. The following methods are recommended for quantifying induced infiltration:

1. *Staff Gauges* - When measuring the stage of a river or stream, at least two gauges should be used. One should be located at the anticipated 5-day cone of depression to monitor ambient river stage trends. The second should be located in the reach of the stream closest to the pumping well. Measurements should be made frequently during the pumping test and recovery periods.

Staff gauges should be secured to prevent movement during flood, ice flow, etc. Use of a stilling well will increase measurement accuracy. Staff gauge elevations should be surveyed at the same time as the observation well network.

2. *Field Measurement of Water Quality* - Measure specific conductance, pH, temperature, and other indicator parameters in samples from the surface water body, production well discharge, and appropriate observation wells before and during the pumping test. Appropriate mass balance equations should be used to estimate the extent of induced infiltration under pumping test conditions.
3. *Vertical Hydraulic Conductivity* - Estimate the vertical hydraulic conductivity of the streambed deposits with field or laboratory techniques and install streambed piezometers and measure the hydraulic gradient between the stream and the aquifer at frequent intervals throughout the test.
4. *Stream Profiling and Stream Gauging* - May be required to supplement induced infiltration evaluations when large volume wells are located near a stream, brook, or river.

D. Flow Measuring Device

A flow measuring device capable of providing instantaneous flow measurements accurate to within $\pm 3\%$ of the pumping rate shall be used.

- E. Discussion of Methodology for delineating Zones II or III (see Section 4.3, *Delineation of Wellhead Protection Zones*).

- F. Pumping Test Discharge Line

The discharge from the pumping test shall be located to minimize the recirculation of water. To decrease fluctuations in the pumping rate at pump startup, it is recommended that the discharge line be filled with water prior to commencement of the pumping test.

- G. Precipitation

Precipitation during the pumping test should be measured *on site* to the nearest one-hundredth (.01) of an inch. Precipitation measurements should commence 5 days prior to startup of the pumping test.

- H. Notice of Intent

Pumping tests conducted in or near vegetated wetlands, or other environmentally sensitive areas, may require filing a Notice of Intent with the local Conservation Commission. The Commission should be contacted to determine if this is needed.

- I. Water Quality Sampling and Testing

Samples should be collected as close to the pump as feasible to minimize possible pipe contamination of the sample.

1. *Exploratory Phase*

During the exploratory phase (2-1/2 inch well) pumping test, the following parameters should be tested for:

- a. Field Tests - The consulting engineer shall be responsible for conducting on-site determinations for pH, odor, specific conductance, and temperature at the beginning and at the end of the pumping test.
- b. Lab Tests - The volatile organic chemicals listed in Appendix A and secondary contaminants must be sampled for at the end of pumping test.

2. *Prolonged Pumping Test*

During the prolonged pumping test the following will apply:

4.2.1 Source Approval Process for Unconfined Aquifer Wells

- a. Field Tests - The consulting engineer shall be responsible for conducting on-site determinations for pH, odor, specific conductance, and temperature minimally at the beginning of the test, after 24 hours, and every two days thereafter until the end of the test. Said determinations shall be recorded in the Source Final Report.
- b. Lab Tests - The consultant supervising the prolonged pumping test shall be responsible for coordination of the sample analyses with a Massachusetts or EPA certified laboratory. Under certain circumstances split samples or duplicates may be required by DEP. The following samples must be collected, using appropriate sampling equipment and protocols, and delivered to the state or EPA certified laboratory.

The laboratory must be certified in all applicable potable water categories, use approved testing methods, and achieve all required method detection limits (MDLs) set by the Commonwealth of Massachusetts.

- (1) Samples of water for total coliform bacteria shall be collected at the projected midpoint and the end of the test.
- (2) Samples for radionuclides shall be collected at end of test (refer to Appendix A).
- (3) Samples for inorganic chemicals and all regulated and unregulated volatile organic compounds (see Appendix A) shall be sampled on the final day of the pumping test prior to shutdown.
- (4) Samples for secondary contaminants shall be collected 1 hour after commencement of the pumping test, every other day thereafter and on the final day of the pumping test prior to shutdown.
- (5) Synthetic organic compound (SOC) waiver - If the proponent of the source intends to apply for a Phase II/V SOC monitoring waiver, the source should be tested for all SOC's listed in Appendix A. New source testing and future compliance testing for SOC's is not normally required for transient noncommunity (TNC) systems.
- (6) Microscopic particulate analysis - Testing may be required if the source fails to meet the Surface Water Treatment Rule exemption criteria set forth in Section 4.1, Step 14. Testing must be conducted in accordance with EPA's Consensus Method for Groundwaters Under the Influence.
- (7) Required analysis for contaminants not described herein shall be at the discretion of the DEP regional source approval staff and shall be based

on site history, well type, regional water quality and geology/hydrogeology.

J. Zoning/Non-Zoning Controls

A draft of the proposed zoning and non-zoning controls must be submitted to the Department for review. The draft should be consistent with requirements set forth in 310 CMR 22.21(2) of the Drinking Water Regulations and apply to the preliminary Zone II for the potential source. Water suppliers subject to "best effort" criteria, as described in Section 4.6, should submit a schedule for meeting these requirements.

V. PUMPING TEST PROPOSAL REVIEW

- A. The DEP Regional Office shall review the pumping test proposal, considering all factors discussed in Section 4.2.1.IV.
- B. Pumping test start-up dates shall be discussed with the DEP regional source approval staff, and a pumping test site visit will be scheduled.
- C. The laboratory selected to analyze all water samples, a water quality sampling schedule, and water quality parameters to be tested for, shall be discussed in the proposal and shall follow the criteria outlined in Section 4.2.1.IV.I.
- D. The pumping test shall be performed in accordance with steps in the Section 4.2.1.IV and Section 4.2.1.VI. The pumping test shall provide sufficient hydrogeologic data to evaluate the Zone II and Zone III for *wells or wellfields with planned yields 100,000 gpd and greater*.
- E. DEP reserves the right to change the number of observation wells, and their proposed location, or other factors influencing the successful completion of this and the previous section.
- F. DEP reviews and comments on the proposed zoning/non-zoning controls; if there are any deficiencies, they are noted to the water supplier. DEP then continues to work with the town/supplier to make passage of required controls feasible.

VI. PUMPING TEST PERFORMANCE

A. Records

Accurate records of the pumping rate, weather conditions (including rainfall measurement), and drawdown of all observation wells, must be maintained during the pumping test and recovery period. Accurate records of the drawdown in the pumping well of large diameter wells must also be maintained during the pumping

4.2.1 Source Approval Process for Unconfined Aquifer Wells

test and recovery period. All drawdown and recovery readings shall be recorded to the nearest 1/4 inch (0.02 feet).

B. Static Water Level Determination

Following the step-drawdown test, the test well and all other pumping wells in the vicinity should be shut down until the previously recorded static water level is reached or for as long as possible. Water levels in all observation wells should then be measured and recorded.

C. Drawdown Measurements

1. *Wells with Planned Yields Less than 100,000 gpd* - Readings shall be taken every minute for the first 10 minutes, every 10 minutes for the first hour and once per hour until shutdown.
2. *Overburden Wells and Wellfields with Planned Yields of 100,000 gpd and Greater* - Drawdown should be measured in all appropriate observation wells with the initial measurement recorded at $t = 0.5$ minute after the commencement of the pumping test. Water levels will then be measured at consistent intervals to include 10 data points for every log cycle beginning with 1 minute, 10 minutes, and 100 minutes, respectively, and twice daily thereafter (frequency of measurements at least 8 hours apart) until the termination of the pumping test. Continuous electronic recording devices or other mechanical or acoustical methods of measurement may be necessary at critical observation wells expected to experience significant early time drawdowns.
3. *Tubular Wellfield Pumping Test* - A minimum of three pumping wells shall be designated as drawdown measuring points, in addition to appropriate observation wells. Drawdown in the designated wells shall be measured by means of a small diameter drop pipe installed through the top cap of the pumping well. The designated wells should be representative of the average well depth, and geologic conditions at the well locations should be representative of conditions throughout the wellfield. One well should be located at or near the center of the wellfield, and one each at or near the opposite extremities. Frequency of measurements will be the same as for overburden wells.

D. Pumping Test Duration and Stabilization

The duration of pumping tests for all wells will be lengthened if the drawdown has not stabilized or if water quality is questionable or changing. The pumping rate must not vary and no shutdowns are permitted during the final 24 hours.

1. *Wells with Planned Yields Less than 100,000 gpd* - The pumping test will be

conducted for a minimum of 48 hours. The well(s) will be considered stable when water level fluctuation is less than 0.5 inches in any 12-hour period, without a change in the pumping rate. This criterion applies to the test well or in special cases to an outlying observation well(s).

2. *Wells with Planned Yields 100,000 gpd and Greater* - The prolonged pumping test shall be conducted a minimum of 5 consecutive days with no more than 2 hours total shutdown per day permitted (stabilization period excluded). The well(s) will be considered stabilized when the drawdown reading recorded at the pumping well(s) or 2-foot observation well has not varied more than 0.5 inches during the final 24 hours.
3. *Tubular Wellfields* - The wellfield will be considered stabilized when the drawdown readings do not vary more than 1.0 inch during the final 24 hours of the pumping test in an observation well located in the middle of the tubular system. No shutdowns are permitted during the final 24 hours of the test.

E. Recovery

1. *Wells and Wellfields with Planned Yields 100,000 gpd and Greater* - Recovery readings should be taken in appropriate observation wells at the same frequency as drawdown readings, beginning at $t = 0.5$ minute after shutdown.
2. *Overburden Wells and Wellfields with Yields Less than 100,000 gpd* - Recovery readings should be taken in the pumping well at the same frequency as drawdown readings, beginning at $t = 1.0$ minute after shutdown.
3. *All Wells* - Readings should be taken for as many days as the pumping well was pumped, or until 95% recovery has been obtained, whichever occurs first.

F. Protective Radius

The protective radius (Zone I) of all unconfined aquifer wells shall be determined based on the equation in the *Definitions*. Also see the graph "Zone I Radius vs. Pumping Rate" (Appendix C).

VII. PUMPING TEST ANALYSIS

- A. When applicable, corrections should be made to the drawdown data to account for ambient water level trends, recharge events, and partial penetration effects.
- B. Determine aquifer transmissivity and storativity for Zone II delineation. Time-drawdown, distance-drawdown, and time-recovery methods should be used, and the results compared and discussed.
- C. Safe Yield Calculation

4.2.1 Source Approval Process for Unconfined Aquifer Wells

1. Overburden Wells with Planned Yields 100,000 gpd and Greater

- a. Calculate Available Water (AW):

Available Water = depth of pumping well - length of screen - static water level - 5 foot safety factor

- b. Calculate Specific Capacity (SC) of the pumping well:

$$SC \text{ (gpm/ft)} = \frac{\text{pumping rate}}{\text{drawdown at stabilization}}$$

- c. Calculate Safe Yield (SY):

$$SY \text{ (gpm)} = AW \times SC \times 0.75 \text{ (safety factor)}$$

2. Tubular Wellfields

- a. Calculate Available Water (AW) in the monitored wells:

If top of screen is greater than or equal to 22 feet below ground surface, then

$$AW = 20 \text{ feet} - \text{ambient water level}$$

If top of screen is less than 22 feet below ground surface, then

$$AW = \text{average depth of test wells} - \text{screen length} - \text{ambient water level} - 2 \text{ foot safety factor}$$

- b. Calculate Safe Yield (SY):

$$SY = \text{Specific Capacity} \times \text{Available Water} \times \text{safety factor} \times \text{number of pumped wells}$$

Safety factor = 0.9, if drawdown stabilizes between July-November,
= 0.75, if drawdown stabilizes between December-June.

VIII. SOURCE FINAL REPORT

The Source Final Report to DEP shall contain, at a minimum, the following:

- A. A final version of the Zone II, including:

1. A description of the subsurface materials based on well logs and other information

2. An evaluation of the hydrogeology based on the data generated during the pumping tests
- B. A description and discussion of the pumping test, including:
1. Ambient water table fluctuation trends
 2. Results of step drawdown test(s)
 3. Selection of pumping rate
 4. Stabilization criteria and well performance
 5. Recovery
 6. Possible effects of changes in barometric pressure
 7. Precipitation and/or recharge events
 8. Approvable yield
 9. Surveyed site plan including Zone I, well locations, and elevations
 10. Any impacts on surface water features
- C. All requirements contained in Section 4.4, *Source Final Report*, and Section 4.6, *Wellhead Protection Zoning and Non-Zoning Controls*.
- D. The Water Management Permit Application for the well must be submitted to the Department at the same time as the Pumping Test Report.

4.2.2 Source Approval Process for Confined Aquifer Wells

- I. GROUNDWATER EXPLORATION (Section 4.2.I)
- II. REQUEST FOR SITE EXAM

The Request for Site Exam must contain a characterization of land use within a 1 mile radius around the well which includes:

1. A map showing:
 - a. Current land uses
 - b. Approved water withdrawals, registered or permitted by DEP and any other private, commercial, or industrial wells
 - c. Zoning
 - d. Existing and potential sources of contamination
2. A discussion/evaluation of potential impacts of existing and potential sources of contamination to the new water supply
3. For test wells installed at potential production well sites, the following must be provided:

4.2.2 Source Approval Process for Confined Aquifer Wells

- a. Water quality analysis results (see Section 4.2.2.V.J)
- b. Estimate of well yield
- c. Well log and as-built construction diagram

Requests for wells with planned yields 100,000 gpd and greater must also include:

1. Location of and geologic logs (depth, yield, lithology) for all exploratory wells.
2. Preliminary conceptual model of the aquifer, including:
 - a. Stratigraphic cross-sections, boundary conditions, recharge areas, etc.
 - b. Preliminary Conceptual Zone II delineation
3. Location and type of potential sources of contamination in the preliminary Conceptual Zone II
4. An estimate of potential production well yield based on initial pumping test conducted on a 2-1/2 inch test well
5. A water quality sample collected prior to the termination of the initial 2 hour pumping test, to be analyzed for parameters discussed in Section 4.2.2.V.J. Water suppliers shall contract a Massachusetts or EPA certified laboratory to conduct analyses on all water samples collected for the Source Approval process.
6. A surveyed site plan including Zone I, well locations, and elevations
7. Strategy for meeting wellhead protection requirements of 310 CMR 22.21(2). This will include, at a minimum:
 - a. Name, title, and phone numbers of lead local contacts who will be pursuing changes to zoning and/or health regulations, pursuing such protection with neighboring communities, and implementing controls that meet DEP requirements;
 - b. Timeframes for drafting any needed changes to bring local controls up to DEP requirements, for bringing regulatory changes to Planning Board, Board of Health, Town Meeting, etc., and a plan for public education that will ensure success in these forums;
 - c. Proposed schedule and contacts for ensuring protection of any part of the Zone II that extends into a neighboring community; and
 - d. Any relevant existing/proposed control measures.

III. DEP SITE EXAM

A site exam shall include, but is not limited to:

1. Land use/sanitary survey of the entire preliminary Zone II by DEP regional source approval staff, the water supplier, and the consultant
2. Discussion of special conditions for pumping test design and performance
3. Identification of any surface water features and discussion of determination of hydraulic connection to the underlying aquifer
4. Discussion of observation well locations to be used during the pumping test
5. The site generally will not be approved for further testing unless the following conditions can be satisfied:
 - a. The site cannot be subject to a significant risk from floods or other disasters unless the finished wells can be properly protected.
 - b. The site can be made readily accessible during all seasons of the year.
 - c. The site is not unduly subject to short-circuiting from a surface body of water.
 - d. The site can meet the Zone I requirements. (See Section 4.3.1.)
 - e. The site cannot be located within 1/2 mile of potentially serious sources of pollution, such as active or abandoned sanitary landfills, major fuel storage or transmission facilities, road salt stockpile areas, or hazardous substances storage areas, unless DEP grants specific written approval. Approved sites are subject to such additional monitoring requirements as may be considered necessary by DEP. In addition to these requirements, all potentially harmful activities within the preliminary Zone II and Zone III must be identified. The proponent's consultant is responsible for alerting DEP to the existence of such hazards. This information shall be shown on a USGS map at a scale of 1:6000 or larger and submitted as part of the Request for Site Exam.
 - f. All test well sites must be approved by the Department prior to submittal of the pumping test proposal. Departmental approval will be in writing and normally shall be granted only after review of the groundwater exploration report (Request for Site Exam), subsequent sanitary survey of the test well site by an engineer from the Department, and, for wells with planned yields 100,000 gpd and greater, a review of water quality data.

Under special circumstances, the Regional Engineer may verbally approve sites

4.2.2 Source Approval Process for Confined Aquifer Wells

for further testing if the above requirements have been met and if a letter of approval will follow. Any substantial changes in site conditions will require re-evaluation.

IV. CONCEPTUAL ZONE II DELINEATION

- A. The Source Approval process for *wells with planned yields 100,000 gpd and greater* requires a preliminary Conceptual Zone II be submitted to the DEP Regional Office with the Request for a Site Exam. (See Section 4.2.2.II.)
- B. A Conceptual Zone II delineation for *wells with planned yields 100,000 gpd and greater* shall be submitted as part of the Source Final Report and shall include, at a minimum, the following:
 - 1. Description and discussion of the stratigraphy and hydrology of the aquifer using USGS geologic maps, any pertinent USGS or other reports, well logs and borings from all available sources including private wells
 - 2. Discussion of the water quality as it relates to the groundwater flow system
 - 3. Map of the surficial geology based on USGS GQ series surficial geologic maps, topographic maps, Hydrologic Investigations Atlas series, field mapping, and review of available subsurface data
 - 4. Regional water table or potentiometric surface map describing groundwater flow directions in the region in which the Conceptual Zone II is located. The map should be constructed based on water levels obtained from production and monitoring wells, USGS observation well network, and hydraulically connected surface water features.
 - 5. Discussion of hydraulic connections among overlying stratigraphic units, including any overlying unconfined aquifer, the lateral extent of the confining layer and estimates of leakage through the confining layer
 - 6. Complete land use/sanitary survey of the Conceptual Zone II
 - 7. Discussion of the hydrogeologic system and the likely sources of recharge to the production well
 - 8. A minimum of two cross-sections through the pumping well, one in the direction of groundwater flow and the other perpendicular to it
 - 9. Discussion of other geological/geophysical data

V. SUBMITTAL OF PUMPING TEST PROPOSAL

The following subsections discuss pumping test design requirements:

A. Planned Pumping Rate

In some cases, a step drawdown test will be required to determine a suitable pumping rate. Information generated during the step test shall be used to predict an appropriate pumping rate that will comply with the stabilization criteria. The well shall not be approved or disapproved by DEP based on the results of the step drawdown test. Documentation and discussion of the results (*e.g.*, water level fluctuations) of the step drawdown test will be presented in the final report with an explanation for the pumping rate chosen for the extended pumping test.

The production well shall be pump tested at the pumping rate for which approval is sought.

B. Antecedent Water Levels

Static water levels and barometric pressure should be measured in all observation wells for a period of 5 days preceding the commencement of the pumping test.

C. Observation Wells

1. *Location and Number* - Observation wells will be required for all wells in confined aquifers. The exact number and location of observation wells will depend on geologic conditions encountered on a site-by-site basis. But, at a minimum, the following will be required:
 - a. *Wells with planned yields less than 100,000 gpd*: One well shall be located in the confining layer and one well in the confined aquifer close to the pumping well to determine aquifer transmissivity and storativity.
 - b. *Wells with planned yields 100,000 gpd and greater*: A minimum of 5 observation wells are required. One well shall be located in the confining layer, one well in the unconfined aquifer, and three wells in the confined aquifer. Well placement must allow for the calculation of aquifer parameters by distance-drawdown as well as time-drawdown methods.
 - c. A plan of the proposed locations and frequency of measurement of all observation wells to be used for drawdown and recovery readings must be included in the pumping test design.
 - d. Elevations and locations of all observation wells must be surveyed to a USGS benchmark relative to mean sea level.
2. *Construction Details* - The depth, diameter, and screened interval must be

4.2.2 Source Approval Process for Confined Aquifer Wells

provided for all wells.

3. *Ambient Well* - One observation well shall be placed outside the Conceptual Zone II, but in the same geologic formation and under confined conditions, to establish ambient water level trends within the aquifer during the pumping test. Water level readings should begin 5 days before startup of the pumping test.
4. *Response Test* - The response of all wells to changing water levels should be tested by either injecting or removing a known volume of water into or from each well and measuring the subsequent rise or decline of the water level. The initial rise of water should be dissipated within a few minutes (to within about 0.01 feet of the initial level).
5. *Quality Control* - Quality control measures which ensure that no contamination is introduced into the aquifer must be employed during the drilling and installation of observation wells. Any observation well permanently abandoned subsequent to the completion of the pumping test should be filled in such a manner that vertical movement of water within the well bore, including movement within the annular space surrounding the well casing, is effectively and permanently prevented, and the water is permanently confined to the specific zone in which it originally occurred. (See Section 4.14, *Well Abandonment and Decommissioning*.)

D. Flow Measuring Device

A flow measuring device capable of providing instantaneous flow measurements accurate to within $\pm 3\%$ of the pumping rate shall be used.

E. Pumping Test Discharge Line

The discharge from the pumping test shall be located to minimize the recirculation of water. In order to decrease the fluctuations in the pumping rate at pump startup, it is recommended that the discharge line be filled with water prior to commencement of the pumping test.

F. Correction for Barometric Pressure

Continuous readings of barometric pressure (to a sensitivity of ± 0.01 inch of mercury) should be made to establish water level trends prior to and during the testing periods. Where appropriate, drawdown data should be adjusted for atmospheric pressure changes occurring during the pumping test.

G. Discussion of Methodology for delineating Zone II or Zone III (see Section 4.3, *Delineation of Wellhead Protection Zones*)

H. Precipitation

Precipitation during the pumping test should be measured *on site* to the nearest one-hundredth (0.01) of an inch. Precipitation measurements should commence 5 days prior to the startup of the pumping test.

I. Notice of Intent

Pumping tests conducted in or near vegetated wetlands, and other environmentally sensitive areas, may require filing a Notice of Intent with the local Conservation Commission. The Commission should be contacted to determine if this is necessary.

J. Water Quality Testing

Samples should be collected as close to the pump as feasible to minimize possible pipe contamination of the sample.

1. *Exploratory Phase*

During the exploratory phase (2-1/2 inch well) pumping test the following should be tested for:

- a. Field Tests - The consulting engineer shall be responsible for conducting on-site determinations for pH, odor, specific conductance, temperature, and carbon dioxide at the beginning and at the end of the test.
- b. Lab Tests - The volatile organic chemicals listed in Appendix A and secondary contaminants must be sampled for at the end of pumping test.

2. *Prolonged Pumping Test*

During the prolonged pumping test the following will apply:

- a. Field Tests - The consulting engineer shall be responsible for conducting on site determinations for pH, odor, specific conductance, and temperature minimally at the beginning of the test, after 24 hours, and every 2 days thereafter until the end of the test. Said determinations shall be recorded in the Source Final Report.
- b. Lab Tests - The consultant supervising the prolonged pumping test shall be responsible for coordination of the sample analyses with a Massachusetts or EPA certified laboratory. Under certain circumstances split samples or duplicates may be required by the department. The following samples must be collected using appropriate sampling equipment

4.2.2 Source Approval Process for Confined Aquifer Wells

and protocol, and delivered to the state or EPA certified lab. Please note that the laboratory must be certified in all applicable potable water categories, use approved testing methods, and achieve all required method detection limits (MDLs) set by the Commonwealth of Massachusetts.

- (1) Samples for total coliform bacteria shall be collected at the projected mid-point of the test, every 5 days thereafter, and at the end of the test.
- (2) Samples for radionuclides shall be collected at the end of the test. Refer to Appendix A.
- (3) Samples for inorganic chemicals and all regulated and unregulated volatile organic compounds (see Appendix A) shall be sampled on the final day of the pumping test prior to shutdown.
- (4) Samples for secondary contaminants shall be collected 1 hour after commencement of the pumping test, every other day thereafter and on the final day of the pumping test prior to shutdown.
- (5) Synthetic organic compound (SOC) waiver - If the proponent of the source intends to apply for a Phase II/V SOC monitoring waiver, the source should be tested for all SOC's listed in Appendix A. New source testing and future compliance testing for SOC's is not normally required for TNCs.
- (6) Microscopic particulate analysis - Testing may be required if the source fails to meet the Surface Water Treatment Rule exemption criteria set forth in Section 4.1, Step 14. Testing must be conducted in accordance with EPA's Consensus Method for Groundwaters Under the Influence.
- (7) Required analysis for contaminants not described herein shall be at the discretion of the DEP Regional Office and shall be based on site history, well type, regional water quality, and geology/hydrogeology.

K. Zoning and Non-Zoning Controls

A draft of proposed zoning and non-zoning controls must be submitted to DEP. The draft should be consistent with 310 CMR 22.21(2) and apply to the Conceptual Zone II for the potential source. Water suppliers subject to "best effort" criteria, as described in Section 4.6, should submit a schedule for meeting these requirements.

VI. PUMPING TEST PROPOSAL REVIEW

- A. The DEP regional source approval staff shall review the pumping test proposal,

considering all factors discussed in Section 4.2.2.V.

- B. Pumping test start-up dates shall be discussed with the DEP regional source approval staff, and a pumping test site visit will be scheduled.
- C. The laboratory selected to analyze all water samples, a water quality sampling schedule, and water quality parameters to be tested for, shall be discussed in the proposal and shall follow the criteria outlined in Section 4.2.2.V.J.
- D. The pumping test shall be performed in accordance with Sections 4.2.2.V and 4.2.2.VII. The test shall provide sufficient hydrogeologic data to evaluate the Zone II and Zone III for *wells with planned yields 100,000 gpd and greater*. (See Section 4.2.2.IV.)
- E. DEP reserves the right to change the number of observation wells and their proposed location or other factors influencing the successful completion of Sections 4.2.2.V and 4.2.2.VII.
- F. DEP reviews and comments on the proposed zoning/non-zoning controls. If there are any deficiencies, they are noted to the water supplier. DEP then continues to work with the town/supplier to make passage of required zoning controls feasible.

VII. PUMPING TEST PERFORMANCE

A. Records

Accurate records of the pumping rate, barometric pressure, weather conditions, including rainfall measurement and drawdown of all observation wells, must be maintained during the pumping test and recovery period. Accurate records of drawdown in the pumping well of large diameter wells must also be maintained during the pumping test and recovery period. All drawdown and recovery readings shall be recorded to the nearest 1/4 inch (0.02 feet).

B. Static Water Level Determination

Following the step-drawdown test, the test well and all other pumping wells in the vicinity should be shut down for as long as possible, or until the previously recorded static water level is reached. Water levels in all observation wells should then be measured and recorded.

C. Drawdown Measurement

1. *Wells with Planned Yields Less than 100,000 gpd* - Readings shall be taken every minute for the first 10 minutes, every 10 minutes for the first hour and once per hour until shutdown. Wells shall be constructed in a fashion allowing

4.2.2 Source Approval Process for Confined Aquifer Wells

for the measurement of water levels in the well casing or borehole.

2. *Wells with Planned Yields 100,000 gpd and Greater* - Drawdown should be measured in all appropriate observation wells with the initial measurement recorded at $t = 0.5$ minute after the commencement of the pumping test. Water levels will then be measured at consistent intervals to include 10 data points for every log cycle of time beginning with 1 minute, 10 minutes, 100 minutes, respectively, and at least twice daily thereafter (frequency of measurements at least 8 hours apart) until termination of the pumping test. Continuous electronic reading devices or other mechanical or acoustical methods of measurement may be necessary at critical observation wells expected to experience significant early time drawdowns.

D. Pumping Test Duration and Stabilization

The test/production well shall be considered stabilized when it meets either of the following criteria:

1. *Wells with Planned Yields Less than 100,000 gpd*
 - a. Forty-eight (48) Hour Pumping Test - The well will be considered stabilized when water level fluctuation is less than 0.5 inch in any 12-hour period. This criterion applies to test/production wells or in special cases to an outlying observation well(s). The pumping test will be extended until stabilization criteria are achieved.

or

 - b. Ten (10) Day Pumping Test - The test/production well shall be considered stabilized if, using a semi-log plot extrapolation of the time drawdown curve derived from the final days of the test and projected over a 180-day period, 10% of the water column (or minimally 15 feet) remains above the intake of the pump if a submersible, or the top of the screen if a turbine. The pumping test will be extended until stabilization criteria are achieved.
2. *Wells with Planned Yields 100,000 gpd and Greater*
 - a. Five (5) Day Pumping Test - The test/production well shall be considered stabilized if the drawdown readings recorded at the pumping well or 2-foot observation well have not varied more than 0.5 inch during the final 24 hours.
 - b. Ten (10) Day Pumping Test - See stabilization criteria described in D.1.b above.

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The pumping rate must not vary, and no shutdowns are allowed during the final 24 hours.

E. Recovery

All Wells - Readings should be taken in appropriate observation wells, at the same frequency as drawdown readings and for as many days as the pumping well was pumped, or until the change in any 24-hour period is less than 2% of maximum drawdown in the pumping well, whichever occurs first.

F. Protective Radius

The protective radius (Zone I) of all confined aquifer wells shall be determined based on the graph, "Zone I Radius vs. Pumping Rate" (Appendix C).

VIII. PUMPING TEST ANALYSIS (See Section 4.2.1.VII.)

IX. SOURCE FINAL REPORT

The Source Final Report to DEP shall contain, at a minimum, the following:

A. A final version of the Conceptual Zone II, including:

1. A description of the subsurface materials based on well logs and other information
2. An evaluation of the hydrogeology based on the data generated during the pumping test

B. Description and discussion of the pumping test, including:

1. Ambient potentiometric surface fluctuation trends
2. Results of step drawdown test(s)
3. Selection of pumping rate
4. Stabilization criteria and well performance
5. Recovery
6. Possible effects of changes in barometric pressure
7. Precipitation and/or recharge events
8. Possible effects on any surface water features within the recharge area
9. Approvable yield
10. Antecedent potentiometric surface data
11. Surveyed site plan including Zone I, well locations, and elevations

C. All requirements contained in Section 4.4, *Source Final Report*, and Section 4.6, *Wellhead Protection Zoning and Non-Zoning Controls*.

4.2.2 Source Approval Process for Confined Aquifer Wells

- D. The Water Management Permit Application for the well must be submitted to the Department at the same time as the Source Final Report.

4.2.3 Source Approval Process for Bedrock Wells

- I. GROUNDWATER EXPLORATION (See Section 4.2.I)
- II. REQUEST FOR SITE EXAM

The Request for Site Exam must contain a characterization of land use within a 1/2 mile radius around the well which includes:

1. A map showing:
 - a. Current land uses
 - b. Approved water withdrawals, registered or permitted by DEP, as well as any other private, commercial, or industrial wells
 - c. Zoning
 - d. Existing and potential sources of contamination
2. A discussion/evaluation of potential impacts of existing and potential sources of contamination to the new water supply
3. For test wells installed at potential production well sites, the following must be provided:
 - a. Water quality analysis results (see Section 4.2.3.VII.H)
 - b. Estimate of well yield
 - c. Well log and as-built construction design

Site exam requests for *wells with planned yields 100,000 gpd and greater* must also include:

1. Preliminary conceptual model of the aquifer, including field evaluation of structural trends, fracture traces and orientation, presence of faults in bedrock outcrops, and the morphologic landscape features relating to these
2. A surveyed site plan, including the Zone I and all well locations and elevations
3. Preliminary Conceptual Zone II delineation, with location and type of potential sources of contamination in the Preliminary Conceptual Zone II
4. Results of preliminary water quality testing

Water quality testing results for the proposed production well must be submitted to the appropriate DEP Regional Office before approval can be given to start the prolonged pumping test. It is recommended that representative, unaerated samples be collected during the installation of a test well or the production well. Water samples shall be sent to a Massachusetts or EPA certified laboratory for analysis.

Preliminary testing shall include the following water quality parameters:

- a. Field Tests - pH, specific conductance, temperature, CO₂ and odor
 - b. Lab Tests -
 - (1) Total coliform bacteria
 - (2) Radionuclides
 - Gross alpha
 - Gross beta
 - Radon
 - (3) All regulated and unregulated volatile organic compounds (listed in Appendix A)
 - (4) Inorganic compounds (listed in Appendix A)
 - (5) Secondary contaminants (listed in Appendix A)
 - (6) Other: ammonia, sediment, sodium, nitrate, and nitrite
5. Strategy for meeting wellhead protection requirements of 310 CMR 22.21(2). This will include, at a minimum:
- a. Name, title, and phone numbers of lead local contacts who will be pursuing any changes to Board of Health and/or zoning regulations, pursuing such protection with neighboring communities, and implementing existing controls that meet DEP requirements;
 - b. Timeframes for drafting any needed changes to bring local controls up to DEP requirements, for bringing regulatory changes to Planning Board, Board of Health, Town Meeting, etc., and a plan for public education that will ensure success in these forums;
 - c. Proposed schedule and contacts for ensuring protection of any part of the Zone II that extends into a neighboring community; and
 - d. Any relevant existing/proposed control measures.

III. DEP SITE EXAM

A site exam shall include, but is not limited to:

1. Land use/sanitary survey of the entire preliminary Conceptual Zone II by DEP regional source approval staff, the water supplier, and the consultant
2. Discussion of special conditions for pumping test design and performance
3. The site generally will not be approved for further testing unless the following conditions can be satisfied:
 - a. The site cannot be subject to a significant risk from floods or other disasters unless the finished wells can be properly protected.
 - b. The site can be made readily accessible all seasons of the year.
 - c. The site is not unduly subject to short circuiting from a surface body of water.
 - d. The site can meet the **Zone I** requirements of Section 4.3.
 - e. The site **should not** be located within 1/2 mile of potentially serious sources of pollution such as active or abandoned sanitary landfills, major fuel storage and/or transmission facilities, road salt stockpile areas, hazardous substances storage areas, etc. Approved sites are subject to such additional monitoring requirements as may be considered necessary by the Department. In addition to the above requirements, all potentially harmful activities within the Conceptual preliminary Zone II must be identified. It is the responsibility of the proponent's consultant to alert the Department to the existence of such hazards. This information shall be shown on a USGS map as part of the Request for Site Exam.
 - f. The Department must approve all test well sites prior to submittal of the pumping test proposal. Departmental approval will be in writing and normally shall be granted only after review of the groundwater exploration report (Request for Site Exam), subsequent sanitary survey of the test well site by an engineer from the Department, and for *wells with planned yields 100,000 gpd and greater*, a review of water quality data.

Under special circumstances, the Regional Engineer may verbally approve sites for further testing if the above requirements have been met and if a letter of approval will follow. Any substantial changes in site conditions will require re-evaluation.

IV. CONCEPTUAL ZONE II DELINEATION

- A. The Source Approval process for *wells with planned yields 100,000 gpd and greater* requires that the preliminary Conceptual Zone II be submitted to the DEP Regional Office with a Request for a Site Exam.
- B. A Conceptual Zone II delineation for a *bedrock well with planned yields 100,000 gpd and greater* shall be submitted as part of the Source Final Report and shall include, at a minimum, the following:
 - 1. Description and discussion of the character of the bedrock aquifer using USGS bedrock geologic maps, pertinent USGS open file reports, and existing well logs and borings from all available sources, including private wells
 - 2. Discussion of the chemical characteristic effects of the rock unit on water quality
 - 3. Map of the surficial geology based on USGS GQ Series surficial geologic maps, topographic maps, field mapping, and review of available subsurface data
 - 4. Regional water table map showing groundwater flow directions in the region in which the Conceptual Zone II is located. The map should be constructed based on water levels obtained from production and monitoring wells, USGS wells and hydraulically connected surface water features.
 - 5. Discussion of hydraulic connections among the bedrock unit proposed to be developed, overburden deposits and surface water features, if applicable
 - 6. A complete land use/sanitary survey of the Conceptual Zone II
 - 7. Discussion of the hydrogeologic system providing recharge to the pumped bedrock well
- C. The following items shall be considered when compiling the Conceptual Zone II delineation:
 - 1. Interpretation of bedrock geologic maps, aerial aeromagnetic and infrared photographs
 - 2. Well logs, geotechnical borings and road borings
 - 3. Geophysical data generated during the compilation of geologic and/or hydrogeologic reports

4.2.3 Source Approval Process for Bedrock Wells

4. Estimates of hydraulic conductivities, total and saturated thicknesses of overlying surficial geologic units derived from well logs, borings, pumping tests and related subsurface explorations
5. A minimum of two geologic cross-sections of the Conceptual Zone II through the pumping well, one in the direction of the groundwater flow and the other perpendicular to it
6. Rose diagram plot of magnitude, density, and orientation of regional rock fractures

V. SUBMITTAL OF PUMPING TEST PROPOSAL

The following subsections discuss pumping test design requirements:

A. Water Level Fluctuation Trends

1. *Wells with Planned Yields Less than 100,000 gpd* - The water level in the production well shall be monitored at least twice daily (minimum 8 hour increments) for a 10-day period ending no more than 5 days prior to the start of the prolonged pumping test. The water level fluctuation trend shall be used during evaluation of the pumping test and application of the stabilization criteria. Long-duration rainfall events may cause postponement of the pumping test. This decision shall be at the discretion of the DEP Regional Office.
2. *Wells with Planned Yields 100,000 gpd and Greater* - The water level in the production well shall be monitored at least twice daily (minimum 8 hour increments) for a 10-day period ending no more than 5 days prior to the start of the prolonged pumping test. The water level fluctuation trend shall be used during evaluation of the pumping test and application of the stabilization criteria. Step tests may not be conducted during this 10-day period. Long-duration rainfall events may cause postponement of the pumping test. This decision shall be at the discretion of the DEP Regional Office.

B. Establishment of a Suitable Pumping Rate

1. A step drawdown test shall be conducted at 50, 100, 150, and 200% of the proposed design well yield.
2. It is recommended that each step be sustained for a minimum of one hour.
3. The water level in the production well shall be allowed to recover 95% of the drawdown prior to the commencement of the prolonged pumping test.

4. Data and information generated during the step test shall be used to predict an appropriate pumping rate that will comply with the stabilization criteria.
5. The well shall not be approved or disapproved by DEP based on the results of the step-drawdown test.
6. Documentation and discussion of the results (*e.g.*, water level fluctuations) of the step-drawdown test will be presented in the final report with an explanation of the pumping rate chosen for the prolonged pumping test.

C. Observation Wells

No observation wells shall be required for pumping tests conducted in bedrock wells unless it is determined by the DEP Regional Office that observation wells are necessary to evaluate the longevity and integrity of the production well or the hydraulic connection to overlying surface water features. Also, private bedrock wells located within the Conceptual Zone II of a potential bedrock public water supply should, if possible, be monitored for water level fluctuations during the pumping test.

The consultant shall report whether any private bedrock wells could be influenced by the pumping test. If private wells will be affected, then these private wells or a representative well will be monitored during the pumping test. If this is not feasible, a bedrock observation well will be drilled in the vicinity of the private wells and will be monitored during the pumping test. The final observation well program will be at the DEP's discretion.

D. Prolonged Pumping Test

1. *Wells with Planned Yields Less than 100,000 gpd*

- a. The production well shall be pumped a minimum of 48 hours at a pumping rate determined by the step-drawdown test to allow the well to meet the stabilization criteria described in Section 4.2.3.VII.D. The duration of the pumping test shall be lengthened if the drawdown has not stabilized or if water quality is questionable.
- b. The production well pumping rate shall not fluctuate more than 10% during the final 36 hours of the pumping test and must not drop below 75% of the pumping test rate during the initial 12 hours of the test.
- c. The discharge may be measured using either a calibrated orifice or bucket measuring technique and must be recorded every 2 hours.
- d. Water levels in the production well shall be measured every 5 minutes for

4.2.3 Source Approval Process for Bedrock Wells

the first 2 hours and once per hour thereafter.

- e. No pump shutdowns will be allowed for the duration of the test. If shutdowns occur, DEP will require the pumping test be rerun.
- f. Foot valves shall be used for all pumps installed in bedrock wells for prolonged pumping tests.

2. Wells with Planned Yields 100,000 gpd and Greater

- a. The production well shall be pumped a minimum of 10 days at a pumping rate determined by the step-drawdown test to allow the well to meet the stabilization criteria described in Section 4.2.3.VII.D. The duration of the pumping test shall be lengthened if the drawdown has not stabilized or if water quality is questionable.
- b. The production well pumping rate shall not fluctuate more than 10% during the final 6 days of the pumping test, excluding shutdown.
- c. The discharge must be measured using a calibrated orifice and must be recorded every 2 hours.
- d. Water levels in the production well shall be measured every 5 minutes for the first 2 hours and once every six hours thereafter.
- e. One pump shutdown not to exceed one hour will be allowed for the duration of the 10-day test. If more than one shutdown occurs, DEP will require the pumping test be rerun; therefore, back-up pumping equipment is suggested.
- f. Foot valves shall be used for all pumps installed in bedrock wells for prolonged pumping tests.

E. Flow Measuring Devices

A flow measuring device capable of providing instantaneous flow measurements accurate to within $\pm 3\%$ of the pumping rate shall be used.

F. Pumping Test Discharge Line

The discharge from the pumping test shall be located to minimize the recirculation of water. In order to decrease the fluctuations in the pumping rate at pump startup, it is recommended that the discharge line be filled with water prior to the initiation

of the pumping test.

G. Correction for Barometric Pressure

Readings of barometric pressure (to a sensitivity of ± 0.01 inch of mercury) should be made to establish water level trends prior to and during the testing periods. Where appropriate, drawdown data should be adjusted for atmospheric pressure changes occurring during the pumping test.

H. Precipitation

Precipitation which falls during the pumping test should be measured *on site* with a rain gauge to the nearest one-hundredth (0.01) of an inch. Precipitation measurements should commence 5 days prior to startup of the pumping test.

I. Notice of Intent

Pumping tests conducted in or near vegetated wetlands, or other environmentally sensitive areas, may require filing a Notice of Intent with the local Conservation Commission. The Commission should be contacted to determine if this is needed.

J. Zoning and Non-Zoning Controls

A draft of proposed zoning and non-zoning controls must be submitted to DEP for review. The draft will be consistent with 310 CMR 22.21(2) of the Drinking Water Regulations and will apply to the Conceptual Zone II for the potential source. Water suppliers subject to "best effort" criteria, as described in Section 4.6, should submit a schedule for meeting these requirements.

K. Discussion of Methodology for delineating Zone II (see Section 4.3, *Delineation of Wellhead Protection Zones*)

VI. PUMPING TEST PROPOSAL REVIEW

- A. The DEP Regional Office shall review the pumping test proposal, considering all factors discussed in Section 4.2.3.V.
- B. Pumping test start-up dates shall be discussed with the DEP regional source approval staff, and a pumping test site visit will be scheduled.
- C. The laboratory selected to analyze all water samples, a water quality sampling schedule, and water quality parameters to be tested for, shall be discussed in the proposal and shall follow the criteria outlined in Section 4.2.3.VII.H.
- D. The pumping test shall be performed in accordance with Sections 4.2.3.V.D. and

4.2.3 Source Approval Process for Bedrock Wells

4.2.3.VII and shall provide sufficient hydrogeologic data to evaluate the Conceptual Zone II for wells with planned yields 100,000 gpd and greater. (See Section 4.2.3.IX.)

- E. DEP reserves the right to add to, delete from, or change the number of observation wells and their proposed location or other factors influencing the successful completion of Sections 4.2.3.V and 4.2.3.VII.
- F. DEP reviews and comments on the proposed zoning/non-zoning controls. If there are any deficiencies, they are noted to the water supplier. DEP then continues to work with the town/supplier to make passage of required zoning controls feasible.

VII. PUMPING TEST PERFORMANCE

A. Records

Accurate records of the pumping rate, barometric pressure, and weather conditions, including rainfall measurement, must be maintained during the pumping test and recovery period. Accurate records of the drawdown in the pumping well must also be maintained during the pumping test and recovery period. All drawdown and recovery readings shall be recorded to the nearest 1/4 inch (0.02 feet).

B. Static Water Level Determination

Following the step-drawdown test, the test well and all other pumping wells in the vicinity should be shut down for as long as possible, or until the wells have recovered 95% of drawdown.

C. Drawdown Measurements

1. *Wells with Planned Yields Less than 100,000 gpd* - Water levels in the production well shall be measured every 5 minutes for the first 2 hours and once per hour thereafter.
2. *Wells with Planned Yields 100,000 gpd and Greater* - Water levels in the production well shall be measured every 5 minutes for the first 2 hours and once every 6 hours thereafter.

D. Stabilization

1. *Wells with Planned Yields Less than 100,000 gpd* - The production well shall be considered stabilized if, using a semi-log plot extrapolation of the time-drawdown curve derived from the pumping test (minimum 48 hours) and projected over a 180-day period, 10% of the water column between the top of the pump and the static water level (or minimally 15 feet) remains above the

pump.

2. *Wells with Planned Yields 100,000 gpd and Greater* - The production well will be considered stabilized if, using a semi-log plot extrapolation of the time-drawdown curve derived from the final days of the pumping test (minimum 10 days) and projected over a 180-day period, 10% (or minimally 15 feet) of the water column remains above the intake of the pump if a submersible or the top of the screen if a turbine.

E. Precipitation Events

1. *Wells with Planned Yields Less than 100,000 gpd* - Precipitation events during the pumping test that result in water level fluctuations exceeding 2% of the total drawdown in the production well will require terminating the pumping test, allowing water levels to stabilize, and conducting another 48 hour pumping test without recharge from precipitation.
2. *Wells with Planned Yields 100,000 gpd and Greater* - Precipitation events that result in water level fluctuations exceeding 2% of the total drawdown in the production well may require terminating the pumping test or extending the pumping test until drawdown meets the stabilization criteria.

F. Approvable Well Yield

The approvable well yield shall be the rate in gallons per day (gpd) at which the stabilization criteria were met times (x) 0.75 safety factor. For example, if the well meets the stabilization criteria when pumping at 100 gpm, the approvable well yield (100 gpm x 0.75 safety factor x 1440 min/day) is 108,000 gpd.

G. Recovery

1. *Wells with Planned Yields Less than 100,000 gpd* - Water levels in the production well shall be measured, after shutdown of the pumping test, once every 5 minutes for the first 2 hours, every 10 minutes for the next 100 minutes, and twice per day thereafter for at least as long as the pumping test was conducted.
2. *Wells with Planned Yields 100,000 gpd and Greater* - Water level in the production well shall be measured, following shutdown of the pumping test, once every 5 minutes for the first 2 hours, every 10 minutes for the next 100 minutes, and twice per day thereafter for at least as long as the pumping test was conducted or until the water level in the well recovers 95% of drawdown at stabilization.
3. Bedrock wells that do not recover at least 75% of the total drawdown within the same number of days for which the prolonged pumping test was conducted

4.2.3 Source Approval Process for Bedrock Wells

shall require reassessment.

H. Water Quality Sampling and Testing

Samples should be collected as close to the pump as feasible to minimize possible pipe contamination of the sample.

1. *Exploratory Phase*

During the exploratory phase (2-1/2 inch well) pumping test the following parameters should be tested for:

- a. Field Tests - The consulting engineer shall be responsible for conducting on-site determinations for pH, odor, specific conductance, and temperature at the beginning and end of pumping test.
- b. Lab Tests - the volatile organic chemicals list in Appendix A and secondary contaminants must be sampled for at the end of pumping test.

2. *Prolonged Pumping Test*

During the prolonged pumping test the following will apply:

- a. Field Tests - The consulting engineer shall be responsible for conducting on-site determinations for pH, odor, specific conductance, temperature, and carbon dioxide minimally at the beginning of the test, after 24 hours, and every two days thereafter until the end of the test.
- b. Lab Tests - The consultant supervising the prolonged pumping test shall be responsible for coordination of the sample analyses with a Massachusetts or EPA certified laboratory. Under certain circumstances split samples must be collected using appropriate sampling equipment and protocol and delivered to the Massachusetts or EPA certified laboratory. Please note that the laboratory must be certified in all applicable potable water categories, use approved testing methods, and achieve all required method detection limits (MDLs) set by the Commonwealth of Massachusetts.
 - (1) Samples for total coliform shall be collected once every five days and the end of the test
 - (2) Samples for radionuclides shall be collected at the end of the test. Refer to Appendix A.
 - (3) Samples for inorganic chemicals and all regulated and unregulated

volatile organic compounds (see Appendix A) shall be sampled on the final day of the pumping test prior to shutdown.

- (4) Samples for secondary contaminants shall be collected 1 hour after the commencement of the pumping test, every other day thereafter and on the final day of the pumping test prior to shutdown.
- (5) Synthetic organic compound (SOC) waiver - If the proponent of the source intends to apply for a Phase II/V SOC monitoring waiver, the source should be tested for all SOC's listed in Appendix A. New source testing and future compliance testing for SOC's is not normally required for TNC's.
- (6) Microscopic particulate analysis - Testing may be required if the source fails to meet the Surface Water Treatment Rule exemption criteria set forth in Section 4.1, Step 14. Testing must be conducted in accordance with the EPA's Consensus Method for Groundwaters Under the Influence.
- (7) Required analysis for contaminants not described herein shall be at the discretion of the DEP Regional Office and shall be based on site history, well type, regional water quality and geology/hydrogeology.

VIII. PUMPING TEST ANALYSIS

- A. Corrections should be made, when necessary, to the drawdown data to account for ambient water level trends, recharge events, and barometric pressure effects.
- B. Approvable Yield Calculation: The approvable yield of a bedrock well will be no more than 75% of the stabilized pumping test rate.

IX. SOURCE FINAL REPORT

Subsequent to the prolonged pumping test (and Zone II delineation for *wells with planned yields 100,000 gpd and greater*), a final report shall be prepared by the engineer or hydrogeologist and submitted to the appropriate DEP Regional Office. The DEP Regional Office shall review the final report and shall either approve or disapprove said report in writing. The report will be accompanied by copies of the Zone II map discussed in Section 4.3.3.

- A. The Source Final Report for all public water supply wells should include, but is not necessarily limited to, the following:
 1. Description of the subsurface materials based on the production well log

4.2.3 Source Approval Process for Bedrock Wells

2. Description of the regional geology based on all available geologic data
 3. Description of the aquifer properties based on all available hydrogeologic data
 4. Description and discussion of the pumping test, including:
 - a. Ambient water table fluctuation trends
 - b. Results of step-drawdown test(s)
 - c. Selection of pumping rate and duration of pumping test
 - d. Stabilization criteria
 - e. Recovery
 - f. Precipitation and/or recharge events
 - g. Water needs, water uses and storage requirements
 5. Discussion of water quality results
 6. Generalized discussion of all the aforementioned elements of this section and a discussion of the geologic features that presumably contribute water to the production well
 7. Listing and discussion of land uses within the Zone I and presumed contributory area that potentially impact water quality or quantity in the production well
 8. Evaluation of data gathered during the prolonged pumping test and recovery
 9. A surveyed site plan showing the location and elevation of the production well
 10. Drawdown readings and recovery readings for the production well, tabulated and presented in a legible form
 11. Graphs showing time-drawdown and time-recovery for the production well
 12. Copies of, or reference to, all relevant correspondence
 13. If treatment is recommended, the unit process shall be discussed (viz., corrosion control, iron and manganese removal and/or control, volatile organic removal, etc.)
 14. Plot plan of the necessary protective radius (Zone I), as described in Section 4.3.1
 15. Discussion of all technical requirements presented in this section
- B. Source Final Reports for public supply wells with planned yields 100,000 gpd and

greater must also comply with the requirements of Section 4.4, *Source Final Report*, and Section 4.6, *Wellhead Protection Zoning and Non-Zoning Controls*.

- C. The Water Management Permit Application for the well must be submitted to the Department at the same time as the Source Final Report.

X. FINAL PRODUCTION WELL CONSTRUCTION AND LONG-TERM WATER QUALITY SAMPLING FOR BEDROCK WELLS

A. Well Construction

Certain engineering or geologic circumstances may require site specific well construction adaptations. It shall be left to the discretion of the DEP Regional Office to allow deviation from the following well construction criteria:

1. *Wells with Planned Yields Less than 100,000 gpd* - Well casing and drilling techniques shall allow for a minimum of 3 inches annular space between the outer diameter of the well casing and the borehole. At the DEP Regional Office's discretion a smaller annular space may be allowed.
2. *Wells with Planned Yields 100,000 gpd and Greater* - Well casing and drilling techniques shall allow for a minimum of 2 inches annular space between the outer diameter of the well casing and the borehole.
3. All bedrock wells shall be cased and sealed a minimum of 15 feet in competent and unweathered bedrock.
4. Steel well casing wall thickness shall be dependent on casing length and shall be determined using American Petroleum Institute (API) or American Water Works Association (AWWA) standards.
5. Recommendations for grouting techniques and materials shall be accompanied by an explanation of selection and shall be presented to DEP during the site visit or earlier in the Source Approval process.
6. A minimum of 35 feet of borehole must be maintained below the top of the pump.
7. Wells shall be developed using either pumping or surging techniques.
8. Source proponents considering well yield enhancement techniques such as explosives, acid scouring and hydrofracturing shall notify the appropriate DEP Regional Office verbally or in writing. The results of the enhancement exercise shall be discussed in the Source Final Report.

4.2.4 Source Approval Process for Springs as Public Water Supplies

9. Drawdown limiting devices shall be built into all bedrock production wells.
10. All bedrock production wells shall be constructed to allow water level measurement at all times through the use of stilling wells or internal hose connections within the well casing and well bore.
11. Pumping equipment shall be selected with capacity no greater than 1.5 times daily approved yield in 24 hours, and shall be capable of operation at the approved yield for extended periods. All pumps with a capacity greater than the approved yield should be equipped with modulating discharge controllers coupled to drawdown sensors in the well. These discharge controllers gradually throttle discharge as dynamic pumping level drops from the theoretical drawdown (based on specific capacity) to shutoff at an elevation 5.0 feet above the top of the pump if a submersible pump, or 5 feet above the top of the screen if a turbine pump is used. As minimum protection, a low water cutoff should be provided. Information on pump curves of the proposed well and a schematic cross-section of the proposed well showing well depth, pump setting, screen setting, and the low water cutoff shall also be submitted.

B. Long-Term Water Quality Sampling

During the first year of production, in addition to the water quality testing requirements stated in 310 CMR 22.00, the water quality in the well shall be tested every three months for the analysis of secondary contaminant parameters by a Massachusetts or EPA certified laboratory. If, after one year, no water quality problems exist, it shall be left to the discretion of the DEP Regional Office to decrease the frequency of sampling for secondary contaminants.

4.2.4 Source Approval Process for Springs as Public Water Supplies

This section provides guidance in determining the yield of springs and evaluating water quality as well as establishing a protective area (Zone I) around springs used as public water supplies.

A spring is a natural discharge point where groundwater issues from soil or rocks in concentrated flow. Public water supply springs will be perennial springs of nonthermal origin.

A source is not considered a spring if mechanical methods are used to induce water. The collection system must not hydraulically affect the water table.

I. REQUEST FOR SITE EXAM AND YIELD TEST PROPOSAL

A report shall be submitted requesting a site exam and presenting a proposal for the

conductance of the yield test. Specifically, the report shall include:

- A. A description of the spring (e.g. depression, contact, joint, etc.) and the geologic/hydrologic features that presumably control the spring yield
- B. A description of the regional geology
- C. A yield test proposal to include:
 - 1. Proposed method of measuring flow
 - 2. Proposed dates of high and low flow measurements
 - 3. Supporting data used to determine high and low flow dates
 - 4. When available, historical high and low flows should be reported
- D. A preliminary discussion of the proposed water collection system
- E. A site plan at 1:6000 scale or larger, including significant topographic features and land uses in estimated Zone I
- F. A location map at 1:25000 scale with land uses within a 1/2 mile radius
- G. A listing of land uses within the estimated Zone I and 1/2 mile radius and a discussion of the associated potential impacts on water quality and quantity.

II. YIELD TEST ANALYSIS AND FINAL REPORT

A. Yield Test

1. *Determination of High and Low Flow Yields*

- a. The yield of a spring shall be calculated for high and low flow conditions. During high flow conditions, yields shall be determined by measuring the discharge for a 10-day period. The same procedure shall be used to determine the average yield during low flow conditions.
- b. Precipitation and/or recharge events shall be recorded during yield tests.
- c. Daily fluctuations of yield should be estimated.
- d. All flow measurements shall be taken at or near the natural point of discharge, prior to inflow or additional sources, and not within the water bearing formation.
- e. Under no circumstances shall mechanical methods be used to induce flow from the spring.

4.2.4 Source Approval Process for Springs as Public Water Supplies

2. *Determination of Variability* - The variability of a spring's discharge should be calculated over a minimum 1-year period. Variability is defined by Meinzer (1923) as "the ratio of discharge fluctuation to its average discharge within a given period of record."

Thus : $V = 100 \frac{(a - b)}{c}$

where: V = variability in percent
a = maximum flow
b = minimum flow
c = average flow

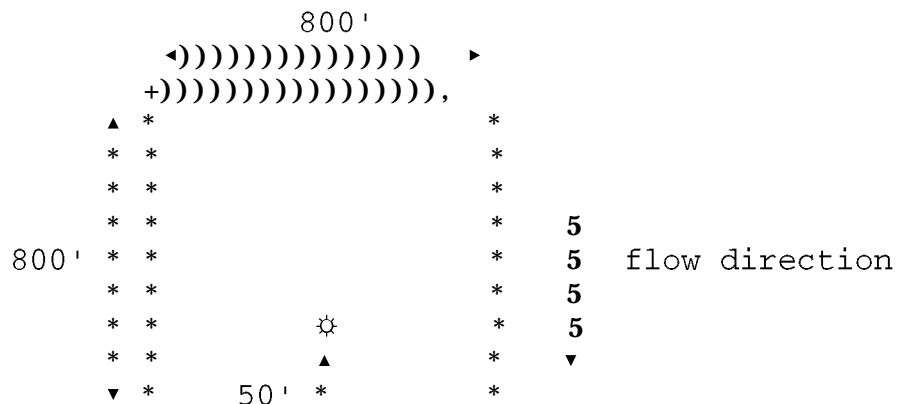
Meinzer, O.E., *Outline of Groundwater Hydrology* , USGS Water Supply Paper #494, pp. 50-55, 1923.

3. All flow measurements shall be taken at the natural point of discharge and not within the water bearing formation.
4. Under no circumstances shall mechanical methods be used to induce water from a spring.

B. Protective Area (Zone I)

1. *Zone I* - The protective area for springs will be a square with sides twice the radius required by the graph, "Zone I Radius vs. Pumping Rate" (Appendix C), (*i.e.*, if the flow rate is 100,000 gpd, the protective radius from the graph in Appendix C is 400 feet, therefore the protective area for this spring would be a square 800 feet on a side). The protective area shall be arranged such that the spring's outlet is 50 feet upgradient and centered in relation to the downgradient side of the square.

The maximum yield (highest historical or average high flow measured) shall be used to determine the size of the Zone I from the graph.



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The requirement to own or control land within the Zone I is the same as for all groundwater sources (Section 4.3.2).

2. *IWPA* - The Interim Wellhead Protection Area for springs is the same as for groundwater sources (see Appendix C). DEP may require the institution of wellhead protection controls for springs yielding 100,000 gpd and greater for all or part of the IWPA.

C. Water Quality Testing

Water quality testing shall be conducted during the 10 day yield measurement test. The schedule for water sampling must be approved by the DEP Regional Office.

The consultant supervising the prolonged yield measurement test shall be responsible for coordination of the sample analyses with a Massachusetts or EPA certified laboratory. Under certain circumstances, split samples or duplicates may be required by the Department. The following samples must be collected using appropriate sampling equipment and protocols, and must be delivered to the Massachusetts or EPA certified laboratory. Please note that the laboratory must be certified in all applicable potable water categories, use approved testing methods, and achieve all required method detection limits (MDLs) set by the Commonwealth of Massachusetts.

1. Samples for total coliform bacteria shall be collected once every day during the test
2. Samples for radionuclides shall be collected at the end of the test. Refer to Appendix A.
3. Samples for inorganic chemicals and all regulated and unregulated volatile organic compounds (see Appendix A) shall be sampled on the final day of the test.
4. Samples for secondary contaminants shall be collected 1 hour after the commencement of the test, every other day thereafter, and on the final day of the test.
5. Synthetic organic compound (SOC) waiver - If the proponent of the source intends to apply for a Phase II SOC monitoring waiver, the source should be tested for all SOC's listed in Appendix A. New source testing and future compliance testing for SOC's is not normally required for TNCs.
6. Microscopic particulate analysis - Testing may be required if the source

4.3 Delineation of Wellhead Protection Zones

fails to meet the Surface Water Treatment Rule exemption criteria set forth in Section 4.1, Step 14. Testing must be conducted in accordance with the EPA's Consensus Method for Groundwaters Under the Influence.

7. Required analysis for contaminants not described herein shall be at the discretion of the DEP Regional Office and shall be based on site history, regional water quality, and geology/hydrogeology.

If bacteria are present, a proposal addressing the type of treatment technique to be used shall be submitted to the DEP Regional Office

D. Final Report

The final report shall include:

1. A description of the spring and the regional geology
2. A description and discussion of yield including:
 - a. Maximum, minimum, and average yields
 - b. Variability of spring yield
 - c. Daily fluctuations of spring yield
 - d. Precipitation and/or recharge events during yield tests
 - e. Water requirements, water use, and storage required
3. A discussion of water quality and proper treatment techniques if necessary
4. Listing and discussion of land uses within the Zone I and estimated contributory area that could potentially impact the quality or quantity of water in the spring
5. A surveyed Zone I map at a 1:6000 scale or larger, including significant topographic features and land uses
6. A location map at 1:25000 scale with land uses within 1/2 mile radius
7. Preliminary discussion of construction of the proposed water collection system

III. LONG-TERM WATER QUALITY SAMPLING

During the first year of production, in addition to the water quality testing requirements stated in 310 CMR 22.00, the water quality in the spring shall be tested every 3 months for the secondary contaminants parameters by a Massachusetts or EPA certified laboratory. This quarterly sampling should occur after precipitation events.

4.3 DELINEATION OF WELLHEAD PROTECTION ZONES

Zone I must be determined for all public water supply wells.

Zones II and III will, in most cases, not be required for DEP approval of public water supply wells with planned yields less than 100,000 gpd. This decision shall be left to the discretion of the DEP Regional Office.

Zone II and Zone III shall be delineated for all public water supply wells with planned yields 100,000 gpd and greater unless the water supplier can demonstrate at the time of submittal of the Source Final Report that a groundwater monitoring well program and an aquifer protection bylaw or ordinance have been implemented that provide suitable water quality protection for the entire Zone III or watershed area. The issues that must be addressed by the groundwater monitoring well program and an aquifer protection bylaw are discussed in Sections 4.5 and 4.6.

Potentially Productive Aquifers: Water suppliers should note that DEP is finalizing regulations to provide higher levels of protection to Potentially Productive Aquifers, as defined in the regulations. These regulations will rationalize hazardous waste clean-up standards based on the likelihood of an aquifer ever being used for water supply.

4.3.1 Zone I Delineation and Protection

For detailed guidance on complying with the Zone I ownership, control, and protection requirements of 310 CMR 22.00, see Appendix D, Draft Policy 94-03A, *Implementation of Zone I Requirements*, and Appendix E, Policy 95-04, *PWS Control of Zone I within Publicly Owned Lands*. For information on Zone I land acquisition procedures, refer to Section 4.10.

I. ZONE I RADIUS

The Zone I radius varies with pumping rate as described in the definitions. Additionally, there is a chart describing how to calculate the Zone I radius in Appendix C.

II. PREFERRED FUEL TYPE

Preferred fuel for pumps, related distribution equipment and treatment systems within the Zone I are:

1. Natural gas, if available, is the preferred type of fuel.
2. Propane gas is the second most preferred. It shall be stored in an approved above-ground tank anchored to a concrete platform which is constructed to a depth just below local frost line.
3. Liquid fossil fuels shall be stored on site only if natural gas or propane is not a viable option. Liquid fossil fuel tanks shall be double-walled and constructed

above-ground inside the pump house and shall be surrounded by an impermeable containment wall, the capacity of which shall be 110% of the fuel storage tank. Leak detection devices shall be emplaced. If fossil fuel storage within Zone I is proposed, a written explanation why natural gas or propane is inappropriate shall be submitted to the DEP Regional Office.

4.3.2 Zone II Delineation and Protection

1. Only Zone II delineations approved by the DEP Regional Office and signed by the Regional Director or his designee will be used and recognized by DEP when implementing any Departmental programs. The Interim Wellhead Protection Area (as per Appendix C) policy of April 4, 1988 shall be used by DEP for public water supplies that have not had Zone IIs approved by the Department.

A copy of the approved Zone II map must be provided by the consultant to the Planning Board at a scale specified by the board. If the approved Zone II extends into another community, the water supplier must send a copy of the approved Zone II map to the Planning Board in that community with a request for assistance in protection of that area.

For those wells requiring a Conceptual Zone II, the following requirements may not apply.

- a. Minimum information necessary for determining the Zone II area:
 - (1) Water table contour map representing conditions typical of the pre-developed long-term average water table for an unconfined aquifer and potentiometric surface for a confined aquifer
 - (2) Hydraulic conductivity, saturated thickness, transmissivity and storage coefficient of the aquifer as obtained from the pumping test and boring logs
 - (3) Nature and characteristics of the aquifer's hydrogeologic boundaries
- b. Recommended procedure for determining Zone II:
 - (1) Construct a water table contour (or potentiometric surface) map representative of pre-developed, long-term average conditions in the aquifer. The map area should include, at a minimum, the preliminary estimate of the Zone II area.
 - (2) Using an appropriate analytical or numerical model, predict the drawdowns by imposing Zone II criteria (180 days of pumping at the approved yield, with no recharge from precipitation). All modelling efforts must follow procedures set forth in Section 4.3.5.

- (3) Determine the Zone II water table contours by subtracting the predicted drawdowns from the long-term average water table contours.
 - (4) Construct a flow net based on the resulting Zone II water table contours.
 - (5) Identify the groundwater divide induced by pumping, which separates the area contributing water to the well (Zone II) from the aquifer area outside Zone II.
 - (6) Extend the groundwater divide upgradient to its point of intersection with prevailing hydrogeologic boundaries.
 - (7) The area defined in this manner is the Zone II for the pumping well.
 - (8) In certain cases where streams or lakes act as recharge boundaries, the extent of the Zone II shall terminate at the nearest edge of this recharge feature relative to the pumping well. The recharging stream or lake would be part of the Zone III just as barrier boundaries (till and/or bedrock) are part of Zone III.
- c. If the downgradient and/or lateral Zone II extents are less than the protective distance required for Zone I, the Zone II shall be extended to include this area.

2. *Zone II Reporting Requirements*

The following minimum information relative to defining Zone II and Zone III should be included in the Source Final Report which is submitted to the DEP Regional Office.

- a. On 11"x 17" paper, outline Zone II and Zone III areas on a USGS topographic map of scale 1:25000, with the map title block (Appendix F). The map title block, signatures and dates must be completed prior to submission of the final report to the DEP Regional Office. Upon approving the site, the regional director or his designee shall sign the document and submit a copy to the DEP Boston Office for filing and transferral of the Zone II boundary onto the water resource overlays.
- b. Minimum of two geologic cross-sections through the pumping well, one in the direction of groundwater flow and the other perpendicular to it
- c. Discussion of the geologic conditions affecting the site, including hydrogeologic boundaries
- d. Water table contour map of pre-pumped water table elevations, corrected for

long-term average conditions, with the location and elevation of all observation wells used in the analysis

- e. Evaluation of data gathered during the prolonged pumping test
- f. Records of pumping rate and weather conditions
- g. Drawdown readings and recovery readings for all observation wells used should be in table form
- h. Where appropriate, graphs showing time-drawdown, distance-drawdown, and time-recovery. The data shall be plotted on semi-logarithmic and log/log graph paper. An arithmetic plot demonstrating drawdowns in all wells observed shall also be constructed for the entire pumping test.
- i. All calculations used to estimate aquifer characteristics
- j. Discussion and comparison of aquifer characteristics based on the two or more methods used
- k. Discussion of the methodology used to define Zone II including calibration and verification of the model, if applicable (Section 4.3.5.)

3. *Model Documentation*

It is the policy of the Department to require complete documentation of the application of a mathematical model to the solution of a hydrogeological problem. Complete documentation includes the following, at a minimum:

- a. Purpose - State the purpose, goals, and objectives of the model.
- b. Conceptual Model - Develop and present a conceptual model of the aquifer system and any contamination problems of concern.
- c. Data Collection - Explain how the data were collected, analyzed, and interpreted.
- d. Model Description - Document the groundwater flow and contaminant transport model (code) used, including the version. Explain why the model was chosen. Describe where model assumptions and actual field conditions do not coincide and how this may affect model results. Any code modifications should be described and justified.
- e. Assignment of Model Parameters - All initial conditions, boundary conditions, hydraulic and transport parameter values should be defined and the reasons for

selecting these conditions justified.

- f. Model Calibration - Model calibration goals and procedures should be presented and discussed. The results of the final calibration run should be presented and analyzed and departure from the calibration targets analyzed. Effects of these departures on the model results should be discussed.
- g. Sensitivity Analysis - Model sensitivity analysis should be presented and interpreted. Discuss how well the model meets the purposes, goals and objectives stated in 5.a. Determine what parameters of the model have the greatest influence on the model results.
- h. Model Validation - Model validation goals and procedures should be presented and discussed. Model or field validation is the comparison of model results with numerical results, independently derived from laboratory experiments or observations in the field.
- i. Model Results - The physical reality of the model should be discussed. Note if the model results support the initial assumptions. The model results should be presented in nontechnical terms.
- j. Model Records - The modeler should provide/keep on file the following records in digital form:
 - (1) The version of the source code utilized
 - (2) The final calibration run
 - (3) All predictive runs

4.3.3 Interim Wellhead Protection Areas

All wells lacking a Zone II should establish an Interim Wellhead Protection Area (IWPA) for wellhead protection. Use the equation in the definitions or the chart in Appendix C to determine the radius of the IWPA for a particular well.

4.3.4 Waiver of Zone II Delineation/Delineation of Zone III

310 CMR 22.21(1)(f) of the Drinking Water Regulations allows communities protecting their Zone III with appropriate zoning and non-zoning controls to avoid delineating a Zone II.

Zone III is defined in the Massachusetts Drinking Water Regulations 310 CMR 22.00. In more simplistic terms, the Zone III can be defined as the surface watershed in which the well is located, excluding those downgradient portions of the watershed which do not contribute water to the well under extreme pumping conditions.

1. The upgradient watershed will be determined from USGS topographic maps. It is

the land area from which surface water drains toward the well. The watershed boundary is established by drawing a line on a topographic map that represents a divide where surface water drains in opposite directions on opposing sides of the line.

2. The downgradient portion of the Zone III will be delineated either by calculation of the downgradient stagnation point created by pumping the well or by use of geologic boundaries, whichever is smaller.
 - a. The downgradient stagnation point will be calculated using the uniform flow equation (Todd, 1980) or other DEP-approved analytical methods from the literature. Transmissivity ($T = Kb$) will be calculated using drawdown data from an observation well located approximately 20 to 100 feet downgradient of the pumping well. The pumping rate (Q) used in the calculation should be the rate for which approval is sought or has already been approved, in the case of existing wells. Existing publications and pumping test information may be used in evaluating aquifer transmissivity and storativity. A line will then be drawn perpendicular to the direction of the regional watershed drainage at the downgradient stagnation point in order to determine the downgradient extent of the Zone III.
 - b. If the downgradient stagnation point encompasses less permeable geologic boundaries, such as glacial till or bedrock, then the downgradient extent of Zone III will terminate at these boundaries.

The downgradient extent of the delineated Zone III will include, at a minimum, all of the Zone I area. DEP discretion will be used when evaluating either method.

Zoning and non-zoning controls must be implemented by abutting municipalities into which the Zone III extends. The proponent community must have demonstrated protection commensurate with 310 CMR 22.21(2).

The required groundwater monitoring well program shall also address the entire Zone III.

Communities should consider the costs and benefits prior to applying for waiver of the Zone II delineation. It shall be left to the discretion of the Department to determine whether a waiver is appropriate considering the local geology, the existing development of the watershed, adequacy of the proposed zoning and non-zoning land use controls, groundwater monitoring well program and the land uses allowed/proposed within the Zone III.

4.4 SOURCE FINAL REPORT

Following the prolonged pumping test (and Zone II delineation for *wells with planned yields 100,000 gpd and greater*), a final report shall be prepared by the engineer or hydrogeologist and submitted to the appropriate DEP Regional Office. The Regional Office will review the final report and either approve or disapprove said report.

Major components of the Source Final Report are:

1. All data from and analyses of the prolonged pumping test
2. The delineated Zone II, if applicable, and Zone III
3. Groundwater monitoring well program
4. Final draft or adopted wellhead protection zoning and non-zoning controls and proposed or adopted map indicating aquifer protection district where controls apply. Evidence of "best effort" to achieve protection of Zone II areas outside of the control of the water supplier must also be submitted at this time.

The Source Final Report should include, but not necessarily be limited to, the following:

1. *Pumping Test*
 - a. Evaluation of data gathered during the prolonged pumping test and recovery.
 - b. A surveyed site plan showing the location and elevation of all test wells, and the location of the production well, with latitude and longitude coordinates.
 - c. Drawdown and recovery readings for all monitored wells, tabulated and presented in a legible form.
 - d. Graphs showing time-drawdown, distance-drawdown, and time-recovery for all monitored wells.
 - e. Copies of the water quality analysis for all samples collected during the test.
 - f. Copies of the lithologic logs for each test hole.
2. Copies of, or reference to, all relevant correspondence.
3. DEP-approved well yields will be expressed in gallons per day (gpd). Pumping equipment shall be selected with capacity no greater than 1.5 times the approved yield (expressed in gpm) and shall be capable of operation at the approved yield for extended periods of time. All pumps with a capacity greater than the approved yield should be equipped with modulating discharge controllers coupled to drawdown sensors in the well which operate to gradually throttle discharge as dynamic pumping level drops from the theoretical drawdown (based on specific capacity) to shutoff at an elevation 5 feet above the top of the screen. As minimum protection, a low water cutoff should be provided. Information on pump curves of the proposed well and a schematic cross-section of the proposed well showing well depth, pump setting, screen setting, and the low water cutoff shall also be

submitted.

4. If treatment is recommended, the unit process shall be discussed (viz., corrosion control, iron and manganese removal and/or control, volatile organic removal, etc.).
5. A surveyed site plan of the Zone I and all well locations and elevations.
6. Source Final Reports for public supply wells with planned yields 100,000 gpd and greater must also comply with the reporting requirements of Section 4.3.4 regarding the delineation of Zones II and III.
7. Model documentation in compliance with Section 4.3.2.3.
8. A discussion of all technical requirements presented in Section 4.3.
9. A discussion of any groundwater withdrawal impacts to surface water features or wetlands, including a discussion of drawdown due to pumping under Zone II conditions.
10. 310 CMR 22.21 requires that a groundwater monitoring well program be implemented for the newly delineated Zone II prior to a source going on line. The intent of the groundwater monitoring well program is to evaluate overall water quality within the Zone II or Zone III, if applicable, evaluate land use impacts on water quality and act as an early warning system for groundwater contamination that may impact the public supply well. The wells shall be installed and monitored by the proponent of the source unless local zoning, bylaws, regulations or site approval criteria require that impacts to groundwater quality from particular land uses be assessed by the landholder.
 - a. The following are examples of land uses that might require the placement of monitoring wells:
 - Sewered or unsewered industrial/commercial areas
 - Unsewered, densely populated residential areas
 - Large scale agricultural areas
 - Landfilling of any type
 - Areas in which contamination has been detected

The groundwater monitoring well network is not meant to evaluate the impacts of all land uses within the Zone II, but to provide a more regional look at groundwater quality and address high risk land use areas such as those listed above. The number of wells necessary to receive Departmental approval is dependent on the land uses within the Zone II and the development density.

b. Inter-Municipal Monitoring Programs

Where Zone IIs cross municipal boundaries, the town in which the source is proposed shall make best efforts to convince abutting towns into which the Zone II extends to allow construction and periodic sampling of groundwater monitoring wells. If properly constructed, groundwater monitoring wells may be strategically located adjacent to roads.

c. Groundwater Monitoring Well Plan Approval

(1) A Conceptual Zone II, submitted with a prolonged pumping test proposal, should be accompanied by a draft groundwater monitoring well plan that includes:

(a) A large-scale map depicting:

- Conceptual Zones II and III boundaries
- The potential production well
- All land uses within the Zone II and Zone III
- Existing and proposed groundwater monitoring wells within Zone II or Zone III

(b) Construction details for existing and proposed monitoring wells

(c) A list of the proposed sampling parameters for each well and the proposed frequency of sampling

(2) At this time, if necessary, the proponent of the source should begin discussions with abutting town(s) concerning locating groundwater monitoring wells in these town(s).

(3) When siting wells to be used for pumping test analyses and the Zone II delineation, the source proponent should, whenever possible, use the same wells for the groundwater monitoring well program.

(4) The final groundwater monitoring well plan shall be submitted as part of the Source Final Report and should include final versions of those items mentioned in Section 4.4.10 above.

(5) The source will not be approved to go on line until all groundwater monitoring wells have been installed and sampling can commence.

(6) The Department may require additional wells after review of the pumping test and Zone II delineation.

- (7) Since the primary purpose of the monitoring well program is the early detection of possible source contaminants, the Department recommends that monitoring wells be fully screened and designed to fully penetrate the aquifer if possible.
- (8) Towns should approach industrial land users within the Zone II to institute a monitoring well program at their expense.
- (9) Water quality results from the monitoring well program shall be kept with the water purveyor and should only be reported to the DEP Regional Office when any detections occur or if otherwise instructed in the Regional Office approval letter. The Regional Office may require additional information from these wells.
- (10) For wells located proximal to a surface water feature that induce a high percentage of recharge from that feature, a discussion of the potential impacts from land uses located proximal to the surface water feature will be provided. This discussion will include, but not be limited to, impacts from land uses located within the Zone III and adjacent to said surface water feature. Land uses located in areas underlain by till and/or bedrock, but in close proximity to the source will also be discussed. Upon evaluation of the submittal, DEP will ensure that the recommended monitoring well program adequately addresses these land uses.

4.5 APPROVAL CONDITIONS

Departmental approval of all new sources shall be at the discretion of the DEP Regional Office. Approval conditions that may be placed on the water supplier include, but are not limited to:

1. Compliance with the Drinking Water Regulations, particularly 310 CMR 22.21, Groundwater Supplies.
2. Satisfactory completion of the Source Approval process.
3. Submittal with the Source Final Report of an approvable groundwater monitoring well program that addresses land uses that might impact public water supplies.
4. Submittal with the Source Final Report of an approvable wellhead protection bylaw or ordinance and district map, or evidence of compliance with best effort criteria. The submittal must address all the criteria listed for sources with planned yields of 100,000 gpd or greater.
5. Any further refinement of the Zone II required after the installation of the final production system, must comply with the Department's requirements.

6. The pumping rate for a new source shall be approved based on the rate at which the pumping test was conducted. For sand and gravel test wells pumping 100,000 gpd and greater, the DEP-*approved pumping rate* can be twice (2x) the rate at which the pumping test was conducted, assuming the well's safe yield as determined by the pumping test is not exceeded. If the pumping test is conducted on the final production well, the approved pumping rate shall not exceed the rate at which the pumping test was conducted. The *approved daily volume* is the approved pumping rate (gpm) times minutes/day and is the maximum allowable volume in any 24-hour period. All DEP Source Approvals shall be issued as an approved daily volume in *gallons per day*.
7. An ENF, and possibly an EIR, must be satisfactorily completed should withdrawal quantities or other threshold criteria trigger MEPA involvement with the project. Withdrawals that meet the criteria set forth in 301 CMR 11.26(7)(h) require an ENF. Any water supply project involving development of a 5,000,000 gpd source also requires an EIR (301 CMR 11.25(6)).
8. *Establishing Approved Yields* - If DEP considers the technical data submitted insufficient to justify establishing a well's approved yield based on doubling of intermediate stage pumping test, another pumping test will be conducted on the final production well at the rate for which approved yield is sought. The pumping test shall go to stabilization and be monitored as was the prior test. Changes in aquifer characteristics, sensitive resources impacted and the extent of the Zone II shall be evaluated thoroughly and discussed with DEP.
9. *Pump Capacity* - DEP will allow the installation of a pump which is rated at 1.5 times the *approved yield* if it is demonstrated that this capability is necessary to meet daily peak demands. If DEP allows the installation of the oversized pump, the following restriction shall apply: the water level in the well must have stabilized during the pumping test and the *approved yield* cannot be exceeded on a daily basis.

4.6 WELLHEAD PROTECTION ZONING AND NON-ZONING CONTROLS

1. Overview

The Massachusetts Drinking Water Regulations (310 CMR 22.00) were amended on July 6, 1990 to include the requirement that communities implement appropriate zoning and non-zoning controls for newly delineated Zone IIs prior to putting a new well on line. This applies to all communities developing new sources with *planned yields of 100,000 gpd or greater* or planning to increase yield of existing wells or wellfields to *100,000 gpd and greater*. The requirement applies to all communities in the Source Approval process that submit a Request for Site Exam after July 6, 1990.

4.6 Wellhead Protection Zoning and Non-Zoning Controls

310 CMR 22.21(2) lists the land uses that must be prohibited in newly approved Zone IIs. Existing land uses are "grandfathered" under zoning laws. The existence of one or more of the prohibited land uses within a Zone II does not necessarily negate the feasibility of constructing a well. The Department shall consider the water quality implications of existing land use prior to approving or disapproving the siting of the well or wellfield.

310 CMR 22.21(2) provides the Department with a standard for determining the comprehensiveness of land use controls proposed by communities. Zoning and non-zoning controls can be a compilation of zoning bylaws or ordinances, rules or regulations.

The Department must approve the zoning or non-zoning controls and the community must implement them prior to receiving Departmental approval to put the source on line, except where "best effort" criteria apply as described in Section 4.6.1.e. below.

Water suppliers must complete the following tasks:

- a. Submit a strategy for meeting wellhead protection requirements of 310 CMR 22.21(2) as part of the Request for Site Exam. This shall include, at a minimum:
 - (1) Name, title, and phone numbers of lead local contacts who will be pursuing any changes to Board of Health and/or zoning or general regulations, pursuing such protection with neighboring communities, and implementing existing controls that meet DEP requirements;
 - (2) Timeframes for drafting any needed changes to bring local controls up to DEP requirements, for bringing regulatory changes to Planning Board, Board of Health, Town Meeting, etc., and a plan for public education that will ensure success in these forums;
 - (3) Proposed schedule and contacts for ensuring protection of any part of the Zone II that extends into a neighboring community; and
 - (4) Any relevant existing/proposed control measures.
- b. A draft of zoning/non-zoning controls that will apply to the subject Zone II and that meet 310 CMR 22.21(2) will be submitted to the Department for review in conjunction with the Pumping Test Proposal. If "best effort" criteria apply, see Section 4.6.1.e.
- c. Submit final draft, if necessary, or newly adopted version of relevant zoning

and non-zoning controls and wellhead protection district map as part of the Source Final Report. Also submit a DEP cross-reference form showing how each of the required wellhead protection criteria have been met.

- d. Implement appropriate zoning or non-zoning controls within the portion of the town that lies within the delineated Zone II of the new source (see 310 CMR 22.21(2)) prior to placing the new public supply well on line. The adopted controls must be submitted with the adopted map of the area to which these controls apply. This should be the same area as the Zone II, or that part of the Zone II in the town that will use the well. This map most often takes the form of an "Aquifer Protection Overlay Zoning District" Map, as adopted by Town Meeting. The Department recommends that the water supplier include monies for the creation of such a map in the RFP for the consultant in charge of the Source Approval process. This will avoid delays in cases where the Planning Board lacks adequate funds to create sufficient maps in a timely fashion.
- e. Best Effort - Communities with municipal water departments must meet the criteria in 310 CMR 22.21(2) within all of the Zone II that is in their municipality prior to putting a new well on line. Water districts and private water companies must make a "best effort" to encourage their community to adopt local control measures meeting 310 CMR 22.21(2) within the part of the Zone II for the new well that falls within their community. Best effort attempts to encourage protection should be ongoing throughout the Source Approval process. Evidence of best effort should be submitted to the Department with the Source Final Report.

Municipal water departments, water districts, and private water companies must use best efforts to convince other towns that comprise the remainder of the Zone II to institute equivalent zoning or non-zoning land use controls.

"Best effort" shall be determined by the Department on a case-by-case basis but shall include, at a minimum, contacting local boards in order to convince them to adopt appropriate zoning and non-zoning controls. Documentation of these attempts shall be in the form of meeting minutes, oral recordings or Memorandum of Understanding between the towns involved. This documentation shall be reviewed by the Department as part of the Source Approval process. The proponent must provide evidence to DEP that a map of the approved Zone II for the new well has been provided to local officials in all communities into which the Zone II extends.

Even if the source proponent is initially unsuccessful in convincing abutting towns to cooperate, the proponent should proceed with the appropriate zoning/non-zoning controls and continue to approach abutting towns annually to get the water resource protection zoning adopted.

4.6 Wellhead Protection Zoning and Non-Zoning Controls

2. *Zoning and Non-zoning Controls - DEP Review*

DEP staff are available to assist towns through the Source Approval process, including the review and implementation of zoning and non-zoning controls. A model Groundwater Protection District Bylaw and two model Board of Health regulations are available from the Department. Source proponents are strongly encouraged to begin planning the zoning/non-zoning controls when the Source Approval process is started. DEP is available to assist the water supplier with water resource protection planning, including the protection of water resources that extend into more than one municipality or state.

The Department will evaluate whether the proposed controls offer protection equivalent to that envisioned under 310 CMR 22.21(2). The adequacy of the town's existing zoning/non-zoning controls for wellhead protection shall be considered when evaluating the comprehensiveness of zoning controls related to the new source.

Many zoning and non-zoning controls include provisions that allow flexibility on the part of the regulating authority to grant a waiver or exemption under certain circumstances. The Department shall review the wording of these provisions as part of all wellhead protection zoning/non-zoning control packages submitted for approval.

Variances from 310 CMR 22.21(1)(e), the requirement to implement zoning/nonzoning controls before putting a source on line, shall be reviewed by the Department on a case-by-case basis following the protocols outlined in 310 CMR 22.21(5). All zoning and non-zoning controls must include variance provisions in order to deal with extreme circumstances and shall describe in detail the enforcement capabilities for all components of the package. Public water suppliers must notify DEP of the subsequent repeal or amendment of any local regulations that were required by 310 CMR 22.21.

3. *Nitrate Loading Analysis*

DEP may, based on certain land use development levels, require as part of the Source Approval process, the completion of a nitrogen loading analysis for the new well's Zone II. This will only be exercised when the level of unsewered and agricultural land use development within the Zone II indicates that nitrate concentrations in the well may in the short or long term exceed the planning goal of 5 mg/L nitrate.

Communities that are required by their Water Management Act permits to define Zone IIs and implement land use controls may be required to conduct a nitrate loading analysis as part of the Zone II delineation for wells that have exceeded the planning goal of 5 mg/L.

Public water suppliers required to perform nitrate loading analyses must then prepare a nitrate management plan which maintains nitrate levels below 5 mg/l for the subject well in the long-term. "Nitrogen Loading Model Guidance" and a computer model are available from the Department.

a. Delineation of Zone IIs for Nitrate Loading Analysis - A Methodology for the Subdivision of a Multi-Well Zone II

Proper application of the nitrate loading model may require that areas of contribution for individual wells be delineated when one Zone II has been delineated for two or more wells. The following procedure enables the Zone II for two or more wells to be subdivided into subzone areas which contribute recharge to each well by delineating groundwater flow paths in two dimensions. In certain circumstances the Department may require additional information in delineating the Zone II for each well.

This procedure requires specific information and entails certain assumptions and limitations.

- (1) DEP-approved Zone II currently exists for the wells for which the nitrate loading model will be applied.
- (2) Groundwater contours can be drawn for the Zone II, and the groundwater elevation data used to determine the groundwater contours can be obtained or estimated for various points within the Zone II from observation well data, topographic elevations of streams and surface water bodies, or a combination of both.

b. Zone II Modelling Methodology - Basic Assumptions/Limitations

- (1) The aquifer is unconfined.
- (2) The aquifer is homogeneous and isotropic. This means the hydraulic conductivity of the aquifer material, or the ability of the aquifer to transmit water, does not vary significantly from one place in the aquifer to another or in any direction.
- (3) Use of surface water elevations to prepare the groundwater contours assumes the elevation of the surface water represents the intersection of the groundwater with the surface water at that point on the topographic map.

c. Steps for Flow Path Analysis

- (1) Obtain a copy of the map showing the approved Zone II and the location of all wells for which the Zone II was determined. This map will be at the

4.7 Conceptual Zone II for Existing Wells

same scale as the USGS topographic map (1:25000 or larger) but typically the Zone II is superimposed over the relevant portion of a USGS map.

- (2) Locate the known and/or estimated groundwater elevations on the map. The groundwater elevations may be obtained from observation well data in the Zone II report and elevations of streams (as groundwater intersections) as shown on the USGS topographic map. From these elevations, plot the estimated groundwater contours across the entire Zone II. Usually the Zone II report filed with DEP includes a groundwater contour map under pumping conditions.
- (3) If necessary, extrapolate to draw the groundwater contours at a more frequent interval and to draw a sufficient number of groundwater flow lines so the "groundwater flow divides" between wells can be estimated. Groundwater flows perpendicular to groundwater contours. These flow lines illustrate the path of water as it is drawn to a specific well. The entire Zone II must be covered by these subzones. Generally, there will be one subzone for each well, although wells in close proximity may share a subzone.
- (4) Boundaries of each subzone are located where the groundwater flow lines diverge between the wells.

4.7 CONCEPTUAL ZONE II FOR EXISTING WELLS

DEP staff have researched the similarities in size, shape, and extent of Conceptual Zone IIs and Zone IIs generated through the use of analytical or numerical techniques. DEP highly recommends that, prior to undertaking a Conceptual Zone II delineation for an existing source, the DEP Regional Office be contacted and the technical approach be discussed.

There is no difference in credibility between Zone IIs that have been delineated using a conceptual approach (analytical model, geological boundaries) versus those delineated using a more complex numerical modeling approach.

A generic Request for Proposals (RFP) is provided in Appendix G to assist the water purveyor in adhering to DEP regulations and guidelines in the delineation of Conceptual Zone IIs for existing sources. Further assistance is available from the Bureau of Resource Protection in Boston.

For Conceptual Zone II delineations completed prior to July 6, 1990, two copies should be sent to the DEP Regional Office for review and comment. If the following technical criteria have been met, the Conceptual Zone II will be approved. If the criteria have not been met, the DEP Regional Office will require whatever technical data are necessary to finalize and approve the Conceptual Zone II delineation.

Completing a Conceptual Zone II delineation for an existing source requires that whatever modeling is undertaken be done at an approved pumping rate or volume.

Frequently, for older wells, the pumping test information is unavailable and pumping rates must be derived from historical annual water supply statistics, another pumping test, or possibly statistics compiled for Water Management Act applications. These data shall be used in one of the following three methods to delineate a Conceptual Zone II.

Method 1: Pumping Test

If a pumping test is the selected method, a pumping test proposal must be submitted to DEP for review and approval. The pumping test shall be conducted at the rate for which approval is sought and shall continue until the well has stabilized. Drawdown and recovery readings shall be acquired as defined in the *PWS Guidelines*. A pumping test report addressing aquifer parameters, drawdown, the well's potential safe yield, and the pumping rate for which approval is sought shall be submitted to DEP for review and approval.

Method 2: Historical Pumping Volumes

If historical pumping volumes are to be used to establish an approvable pumping rate, all available historical data should be used to smooth out any unusual periods of time with significant fluctuations in the pumping schemes.

The approvable daily volume shall be calculated by determining the average daily volume pumped for the history of record. If a well has been off-line for a period of time, that time should be subtracted from the pumped volume per unit time calculations. Calculations shall be based on days of pumping, not hours of pumping. The volume of water pumped from a well during any 24-hour period shall constitute one day's volume.

Method 3: Monthly Averaged Volume

Conceptual Zone IIs may be delineated for wells based on pumping averaged over the period of an entire month. The period selected may be the high month of record but devoid of any extenuating circumstances that may have caused excessively higher than normal pumping rates.

The approvable daily volume shall be calculated by determining the average daily volume for the selected month. Calculations shall be based on days of pumping, not hours. The volume of water pumped from a well during any 24-hour time interval shall constitute one day's volume.

A Conceptual Zone II is a delineated zone of contribution in which a combination of analytical and surficial geologic mapping techniques are applied. Based on the findings,

4.7 Conceptual Zone II for Existing Wells

the DEP will approve Conceptual Zone II's for existing sources if they meet the following technical criteria:

1. A Conceptual Zone II delineation for *wells with planned yields 100,000 gpd and greater* shall, at a minimum, include the following:
 - a. Description and discussion of the stratigraphy and hydrology of the aquifer using USGS geologic maps, any pertinent USGS or other reports, well logs, and borings from all available sources, including private wells.
 - b. Discussion of water quality as it relates to the groundwater flow system.
 - c. Map of the surficial geology based on USGS GQ series surficial geologic maps, topographic maps, Hydrologic Investigations Atlas, field mapping, and review of the available subsurface data.
 - d. Regional water table or potentiometric surface map showing groundwater flow directions in the region in which the Conceptual Zone II is located. The map should be constructed based on water levels obtained from production and monitoring wells, USGS observation well network, and hydraulically connected surface water features.
 - e. For aquifers under confined conditions, a discussion of the hydraulic connection among overlying stratigraphic units, including any overlying unconfined aquifer, the lateral extent of the confining layer and estimates of leakage through the confining layer.
 - f. Complete land use/sanitary survey of the Conceptual Zone II.
 - g. Discussion of the hydrogeologic system and the likely sources of recharge to the production well.
 - h. A minimum of two cross-sections through the pumping well, one in the direction of groundwater flow and the other perpendicular to it.
 - i. Other geological data.
2. It will be left to the DEP Regional Office's discretion to require monitoring wells where potential adverse impacts on the water supply exist. These wells will be used for water quality testing and for stratigraphic well log information.

4.8 REDELINEATION OF ZONE II

The following describes the process for the redelineation of DEP approved Zone IIs. Redelineations will be considered based on the submittal to DEP of new or improved geologic and

hydrogeologic information. The redelineation will include the entire Zone II.

The Zone II redelineation process consists of two phases:

I. PHASE I

1. Submittal of a detailed hydrogeologic pumping test proposal and payment (if applicable) of the DEP permit fee (BRP WS-07)

The following, at a minimum, must be submitted with the proposal and fee (if applicable) for consideration by DEP to proceed with the redelineation:

- a. Discussion of technical rationale for redelineation including a conceptual model of the redelineated Zone II.
 - b. The number and location of boring or monitoring wells or other forms of subsurface investigative work that will be undertaken as part of the redelineation
2. The proponent must notify the water supplier of the proposed Zone II redelineation
 3. DEP will review the proposal based on timelines.
 4. DEP will coordinate a technical meeting with the project proponent to discuss the criteria required to redelineate a DEP approvable Zone II.
 5. The proponent concurs with DEP requirements for data acquisition and resubmits the final proposal for redelineation.

II. PHASE II

1. The proponent conducts a field investigation to acquire the necessary information as per discussion in Phase I.
2. The sophistication of the Zone II modelling effort will be of an equal or greater level than the original modelling effort.
3. The Zone II and all pertinent data will be submitted by the proponent to DEP for evaluation along with payment (if applicable) of the DEP permit fee (BRP WS 08).
4. Based on criteria established in Phase I and in compliance with directives provided for the delineation of Zone II in appropriate sections of this document, DEP will approve or disapprove the redelineation.

4.9 ZONE II METHODOLOGY FOR WELLS WITH PLANNED YIELDS LESS THAN 100,000 GALLONS PER DAY

The Zone II methodology for *wells with planned yields less than 100,000 gpd* will be consistent with the Zone II approach currently in effect for *wells with planned yields 100,000 gpd and greater*. In most cases a numerical model will not be required unless extenuating circumstances dictate that this approach will provide the only acceptable level of wellhead protection. Generally the Zone II will be delineated using hydrogeological mapping and simple mathematical techniques (e.g., uniform flow equation).

The minimum information required to employ this delineation method includes:

1. The well's pumping rate, usually obtained from historical pumping records
2. A hydraulic gradient, usually interpreted from USGS topographic maps
3. Saturated thickness, as determined from maps or well logs
4. Hydraulic conductivity, in lieu of pumping test information, could be determined from USGS Hydrologic Atlas, geologic logs, etc.

In some cases, the methodology that has been developed for delineating Zone IIs for *wells with planned yields 100,000 gpd and greater* will not be appropriate for low yield wells. Very low pumping rate wells located in or adjacent to glacial till and/or bedrock do not lend themselves to Zone IIs that adequately protect the wellhead. In these cases, methods to be considered to produce more realistic Zone IIs will include mass balance calculations to determine upgradient Zone II limits, utilization of topographic contours for flowpath analysis and equating hydraulic conductivity values to pumping rates for bedrock wells.

4.10 LAND ACQUISITION FOR WELLHEAD PROTECTION

Section 310 CMR 22.21 of the Massachusetts Drinking Water Regulations require the acquisition or control as described in Section 4.3.1 of Zone I. In determining the protective distance to be acquired, the "Zone I Radius vs. Pumping Rate" graph (Appendix C) should be used.

The land acquisition procedures for Zones I, II, and III are as follow:

1. The land acquisition procedure should be initiated once a decision has been made to develop a permanent water supply at a given site.
2. Chapter 40, Section 41 of the Massachusetts General Laws, as amended, requires water suppliers to obtain the consent and approval of the Department before acquiring lands for the protection of water supply source by any means, subject to public notice and hearing. Permit Application BRP WS 26 and permit fees, if applicable, must be submitted to the Department.

3. The Department must receive, in writing, from the water supplier, a request for the acquisition of said land. The request shall incorporate a site plan in sufficient detail to draw a legal deed, the current names and addresses of the land owners and acreage involved. The names and addresses of abutters should also be submitted. The Department shall make all necessary arrangements for the conduct of the public hearing and will notify all parties of the time and place of the hearing.
4. Subsequent to the public hearing, the Department shall either approve, modify, or disapprove the land taking and shall so notify the water supplier in writing. Upon receipt of the Department's approval, the water supplier may proceed with the land taking. A copy of the approved plan shall be filed with this Department and with the appropriate registry of deeds by the water supplier.

4.11 FINAL APPROVAL OF THE COMPLETED WATER WORKS

1. Every well shall be tested for plumbness and alignment in accordance with AWWA standards. The test method and allowable tolerance shall be clearly stated in the specifications. If the well fails to meet the requirements, it may be accepted by the engineer if it does not interfere with the installation or operation of the pump or uniform placement of grout.
2. When the permanent well and water works are complete, the Department shall be notified by the supplier of water and/or consulting engineer in order that a facility examination can be made. Bacteriological and chemical analyses shall be made on samples of water from the completed works. The Department must approve the construction prior to the facility being placed in use.

4.12 OTHER PERMIT REQUIREMENTS IN THE SOURCE APPROVAL PROCESS

This section and the associated flow chart (Appendix I) show the other state and federal agencies that are involved in the Source Approval process, what each agency requires, and at what phase of the process specific information must be submitted regarding the proposed new source for public water supplies. Recently some confusion has arisen as to the involvement state and federal agencies, including the U.S. Army Corps of Engineers (ACOE), DEP Watershed Management Program, DEP Wetlands and Waterways Program, Massachusetts Environmental Policy Act (MEPA) Office, and Department of Environmental Management (DEM) have in the development process of public groundwater supplies. All permits may not be required for every new source, but will depend upon a number of factors, including the alteration of wetlands, yield of the well, and ownership of the property.

Groundwater source development frequently involves state and federal agencies other than DEP when sites are located on state-owned parkland or when the development processes impact

4.12 Other Permit Requirements in the Source Approval Process

wetlands from activities such as construction of temporary and permanent access roads, construction of permanent pumping and/or treatment facilities, and long-term drawdown of groundwater levels. To avoid long and costly delays or possible prohibition of well installation, DEP strongly recommends that information be submitted in a timely and complete fashion to the agency having jurisdiction. Permission to access state-owned parklands to conduct groundwater exploratory work should be obtained from DEM early in the Source Approval process before any exploratory drilling is conducted.

DEP requires identification and assessment of wetlands impacts during the Source Approval process to ensure that the Army Corps of Engineers, DEP Wetlands and Waterways Program, and DEP Watershed Management Program receive the information necessary for prompt evaluation of permit applications. DEP recommends that water suppliers or their consultants identify all practicable means to avoid, minimize, and mitigate impacts early in the Source Approval process to prevent delays.

I. EXPLORATORY PHASE

Prior to the submittal of a Request for Site Exam to DEP, the following permits may be required if the exploratory work is to be conducted in or near wetlands or on state owned parkland.

A. DEP Wetlands and Waterways Program

1. *Order of Conditions* - This permit approves work pursuant to the Massachusetts Wetlands Protection Act. Public water suppliers should file a Notice of Intent. Special provisions regarding the exploration for new public water supplies are contained in the Wetlands Protection Act Regulations 310 CMR 10.53 (3) (o).
2. *Massachusetts 401 Water Quality Certification* - this permit certifies that the project complies with state water quality standards. The 401 permit should be applied for and obtained prior to the Army Corps of Engineers Section 404 permit application. The Army Corps of Engineers generally requires the issuance of the 401 Water Quality Certification prior to issuance of the Section 404 permit.

The allowable duration of temporary roads and structures will be regulated within the permitting process.

B. Department of Environmental Management: Special Use Permits

The following describes the process for the exploration and development of public water supply wells on DEM property. Development of public water supplies on DEM property should only be considered under exceptional circumstances, which is defined as the solution to a significant hardship for which there is no other feasible alternative. If a proponent is interested in conducting exploratory work on

DEM property, they should make a written request to the Director of Forests and Parks with a copy to DEM's Director of Water Resources. If approved, DEM will issue a Special Use Permit granting permission to access public parkland for a specified period of time to conduct an exploratory well investigation program. Exploratory work will not be conducted within 400 feet of all trails, paths, recreational land uses or any other DEM permitted land uses, such as agriculture. A special request must be submitted for the installation of temporary roads and all property must be restored to its original condition upon completion of the project.

The issuance of a Special Use Permit for test wells for exploratory purposes does not imply approval by the DEM for construction of a permanent well (public water supply) on conservation/recreation land. Such permits are only to facilitate general planning and feasibility studies.

Any access gained to the property, or exploratory work done without a Special Use Permit, will preclude that well site from being considered by DEM for approval.

II. REQUEST FOR SITE EXAM

The following permits may be required at the Request for Site Exam phase.

A. Army Corps of Engineers: Section 404 Permit

This permit is required when any filling of wetlands occurs in the process of well site exploration or well development. To meet the requirements for a Section 404 Permit, an Alternative Analysis must be conducted. This analysis will primarily be conducted in two phases. The first phase will be conducted at the time of the Request for Site Exam, and the second phase will be submitted with the Source Final Report. As part of the first phase, a statement of the Basic Project Purpose should be submitted concurrently with the Request for Site Exam. This is the most important part of the Section 404 permit application process as it is the foundation of the Corps' evaluation in determining whether to issue the permit.

As part of the Request for Site Exam, the following information should be included:

1. *Basic Project Purpose* - Since the first phase of the Alternative Analysis, which includes the Basic Project Purpose, is the most important part of the process and may determine whether the Army Corps of Engineers will issue the Section 404 Permit, it should be as comprehensive as possible, developing a strong argument why the selected site is the preferred well location to the exclusion of all other sites or alternatives.

A statement of the basic project purpose as well as discussions of the expected short and long term impacts is required. The discussion should be based on

4.12 Other Permit Requirements in the Source Approval Process

information obtained during the groundwater exploration phase of the Source Approval Process, specifically information relating to baseline seasonal water levels and estimates of drawdown due to pumping.

Items in the discussion to support the basic project purpose should include the following:

- a. Volume that will be required
 - b. Reasons project is being undertaken
 - c. Needs or goals
 - d. Constraints placed on applicant by other programs (DWS, WMA)
 - e. Use and purpose of new source
2. Items in the discussion to support the alternative analysis should include the following:
 - a. Discussion of all sources considered
 - b. Justification for selected site
3. Wetlands information should include:
 - a. Definition and description of the type(s) of wetland potentially impacted including a characterization of functions and values.
 - b. Data should be gathered to support an estimate of the functional values of the waters and wetlands which are likely to be affected by the project.
 - c. For each affected wetland, an assessment should be prepared addressing at least the following wetland functions:
 - (1) Groundwater recharge/discharge
 - (2) Flood storage and desynchronization
 - (3) Sediment and shoreline stabilization
 - (4) Sediment, toxicant, pathogen retention/transformation
 - (5) Nutrient retention/transformation
 - (6) Nutrient export
 - (7) Aquatic diversity/abundance
 - (8) Fish and shellfish habitat

- (9) Wildlife habitat
 - (10) Endangered species
 - (11) Consumptive recreation (e.g., hunting, fishing)
 - (12) Nonconsumptive recreation (e.g., boating, aesthetics)
 - (13) Uniqueness/heritage
 - (14) The proponent will conclude whether or not each of the listed functions is a principal valuable function of the wetland and briefly explain any available data
 - (15) General discussion of potential impacts to downstream wetlands
 - (16) Discussion of options considered to minimize the impacts
4. A map of the wetlands area should include:
- a. Surveyed site plan of property with both existing and proposed contours
 - b. Stake out a field delineation of waters and wetlands. Delineation should be made in accordance with the Massachusetts Wetlands Protection Act, as specified in the Wetlands Protection Act Regulations (310 CMR 10.00), and in accordance with the Federal Clean Water Act as specified in the Corps of Engineers Wetland Delineation Manual, Technical Report Y-87-1, January, 1987. These two delineations may or may not coincide.
 - c. A plot of the limits of the waters and wetlands, and the general limits of each wetland type on surveyed site plan
 - d. The proposed footprint of the entire project, including buildings, roadways, parking areas, etc., and limits of all fill to be placed in waters and wetlands should be shown on the surveyed site plan
5. Discussion of potential wetland replication necessary and proposed methods of mitigation for the principal valuable function impacted.

Mitigation may be required in accordance with the following:

- a. Mitigation for the Army Corps of Engineers should be in accordance with the Memorandum of Understanding Between EPA and the Department of the Army concerning the Determination of Mitigation Under the Clean Water Act Section 404 (b)(1) Guidelines.

4.12 Other Permit Requirements in the Source Approval Process

- b. Mitigation for the Massachusetts Wetlands Protection Act should be proposed in accordance with 310 CMR 10.00, and the Order of Conditions issued under the Wetlands Act.

One full year of quarterly wetland monitoring (water level) data is required for wells with an approved yield of 100,000 gpd and greater. This may be in the form of hand driven points in wetland deposits and underlying deposits. The location and number of monitoring wells will be reviewed and approved by DEP in consultation with DWW prior to installation. Wetland monitoring results should be submitted with the pumping test report.

Discussion should be limited to 2-3 pages. Periodic meetings between DEP and Army Corps of Engineers will be held to discuss permit applications.

III. PUMPING TEST PROPOSAL

A. Department of Environmental Management: Special Use Permit

Application must be made to DEM for a Special Use Permit to conduct the prolonged pumping test.

If a favorable site is located on DEM property, the proponent must formally request permission from DEM to conduct further water supply development work including installation and testing of production and observation wells. The request should be submitted to the Director of Forests and Parks, with a copy to the Director of Water Resources. Only requests from municipal water departments, water districts, public water supply agencies or companies, or other public entities will be entertained by DEM.

The request must state the basic project purpose and alternative analysis as outlined in DEM's *Policies and Procedures For the Disposition of Land, Water or Interests Therein* including:

1. Demonstrating that the proposed water supply withdrawal shall be the only feasible source available to correct an immediate public health problem or a projected long-term water supply deficit
2. Demonstrating that the withdrawal shall have no significant adverse environmental impact upon critical natural resource values on the property; or the volume/time of withdrawal is conditioned to adequately address the potential impact(s)
3. The implementation of (a) a water conservation plan approved by the Water Resources Commission and (b) either watershed protection or aquifer protection measures

4. Demonstrating that the water supply withdrawal shall not cause unacceptable impacts upon the operation, management, or delivery of the conservation, open space or recreational programs of DEM
5. Demonstrating that the withdrawal shall comprise the only source available at comparable costs, quantity, or long range availability
6. The water supply withdrawal shall adhere to and meet the conditions and permitting requirements of all applicable local state and federal laws, regulations and policies
7. A surveyed site map of the area showing all recreational uses

If further water supply development work is approved, DEM will issue a Special Use Permit to access the land and perform a prolonged pumping test.

B. Massachusetts Environmental Policy Act (MEPA)

An Environmental Notification Form (ENF) can be filed with MEPA at this stage of the source approval process or as late as submittal of the Source Final Report. The filing initiates a 30-day public review period, which commences with a notification in the Environmental Monitor of the availability of the ENF. During the ENF review, the environmental impacts associated with the proposed well are evaluated. For projects with significant environmental impacts, the ENF review can result in a requirement for the preparation of an Environmental Impact Report (EIR). However, if an EIR is not required, the MEPA review is complete at the end of the public comment period.

IV. SOURCE FINAL REPORT

A. Army Corps of Engineers: Section 404 Permit

1. Detailed discussion of hydrologic impacts due to construction of and withdrawals from the final pumping well
2. Discussion of options considered to minimize the impacts
3. Discussion of withdrawal impacts on downstream wetlands
4. Discussion of impacts associated with the withdrawal based on a proposed pumping schedule. An additional pumping test or modelling effort approved by DEP at the proposed pumping schedule may be required to demonstrate long-term drawdown and recovery
5. Replication plans should be submitted at this time. The Corps requires

4.12 Other Permit Requirements in the Source Approval Process

mitigation which replicates the "function and values" of the impacted wetlands.

6. Survey sample plots should be identified at this time for long term monitoring under the withdrawal permit for the Water Management Act.
7. Public notices for DEP and the Army Corps of Engineers shall be executed at this time

C. DEP Water Management Program: Water Management Act Permit

The Water Management Act, which is administered by DEP, regulates water withdrawals which exceed 100,000 gallons per day. Issuance of this permit ensures protection for the needs of competing water uses, natural resources, and the safe yield of each water source.

D. DEP Wetlands and Waterways Program Permits

1. *Order of Conditions* - This permit approves work pursuant to the Massachusetts Wetlands Protection Act. Public water suppliers should file a Notice of Intent. Special provisions regarding the construction and development of new public water supplies are contained in the Wetlands Protection Act Regulations 310 CMR 10.53 (3) (o).
2. *Massachusetts 401 Water Quality Certification* - This permit certifies that the project complies with state water quality standards. The 401 permit should be applied for and obtained prior to the Army Corps of Engineers Section 404 permit application. The Corps generally requires the issuance of the 401 Water Quality Certification prior to issuance of the Section 404 permit.

E. Department of Environmental Management: Approval of Transfer

A copy of the pumping test report must be submitted to DEM. If the DEM Lands Committee has approved the site for well development and transfer to the proponent, DEM submits a transfer request (Form TR1) to the Division of Capital Planning and Operations (DCPO) for transfer of the property to the proponent. A surveyed map including any property easements, utility easements, accessways, the Zone I and neighboring land uses must be submitted to DCPO. It is recommended that the proponent contact DCPO for specific instructions on survey map requirements. DCPO will poll state and local agencies to determine if any interest exists in the property. DCPO will also conduct an appraisal of the property to determine its value.

Concurrent with the Lands Committee's approval for further water supply development work, DEM will file legislation to transfer the state owned property (Article 97 land) to the proponent.

4.13 GENERAL WELL CONSTRUCTION

4.13.1 Screens Shall:

1. Be constructed of material resistant to damage by chemical action of groundwater or cleaning operations
2. Have size of openings based on sieve analysis of formation and/or gravel pack materials
3. Have sufficient diameter to provide adequate specific capacity and aperture entrance velocity which should not exceed 0.1 feet per second

4.13.2 Grouting Requirements

All permanent well casing, except driven Schedule 40 or greater steel casing, when used as a seal and with the approval of the DEP Regional Office, shall be surrounded by a minimum of 1-1/2 inches of grout to the depth required by the DEP Regional Office. All temporary construction casing should be removed, but shall be withdrawn at least 5 feet to insure grout with the native formation.

1. Neat Cement Grout

Cement conforming to ASTM standard C150 and water, with not more than 6 gallons of water per 94 lbs. Type II cement, must be used for 1-1/2 inch openings.

2. Concrete Grout

- a. Equal parts of cement conforming to ASTM standard C150, with not more than 6 gallons of water per 94 lbs. Type II cement, must be used for openings larger than 1-1/2 inches.
- b. Where an annular opening larger than 4 inches is available, gravel not larger than one-half (1/2) inch in size may be used.

3. Clay Seal

A pressure grouted clay slurry may be used when approved by the DEP Regional Office.

4. Application

Grouting shall take place by pressure or tremie pipe and shall be applied from the bottom of the section being grouted upward and should be completed in one

continuous motion. After cement grouting is applied, work on the well shall be discontinued until the cement or concrete grout has properly set.

4.13.3 Upper Terminal Well Construction

1. Permanent casing for all groundwater sources shall project at least 12 inches above the pumphouse floor or concrete apron surface and at least 18 inches above final ground surface.
2. Where a well house is constructed, the floor surface shall be at least 6 inches above the final ground elevation.
3. The top of the well casing, at sites subject to flooding, shall terminate at least 2 feet above the 100-year flood elevation, or as the Department directs.

4.13.4 Development

1. Every well shall be developed to remove the native silts and clays, drilling mud and/or finer fraction of the gravel pack.
2. Where chemical conditioning is required, the specifications shall include provisions for the method, equipment, chemicals, testing for residual chemicals, and disposal of waste and inhibitors.

4.13.5 Capping Requirements

1. A welded metal plate or locking threaded cap is the preferred method for capping a well.
2. At all times during the progress of work, the contractor shall provide protection to prevent tampering with, or entrance of foreign materials into, the well.

4.13.6 Aquifer Types and Construction Methods - Special Conditions

1. *Sand and Gravel Wells*
 - a. If clay or hard pan is encountered above the water bearing formation, the permanent casing and grout shall extend through the clay or hardpan.
 - b. If a sand or gravel aquifer is overlain by permeable soil, the permanent casing and grout shall extend to at least 20 feet below original or final ground evaluation, whichever is lower.
 - c. If temporary casing is used, it shall be completely withdrawn as grout is applied.

2. *Gravel Pack Wells*

- a. Gravel pack shall be well rounded particles, 95% siliceous material, smooth and uniform, free of foreign material, properly sized, washed and then disinfected immediately prior or during placement.
- b. Each gravel pack shall be tremied in place in one continuous operation.
- c. Gravel refill pipes shall be Schedule 40 steel pipe incorporated within the pump foundation and terminated with threaded or welded caps at least 12 inches above the pump house floor or concrete apron.
- d. Protection from grout leakage into the gravel pack or screen shall be provided.

3. *Dug Wells*

- a. A watertight cover shall be provided.
- b. Minimum protective lining and grouted depth shall be at least 10 feet below original or final ground elevation, whichever is lower.
- c. Opening shall be curbed and protected from entrance of foreign material.
- d. Pump discharge piping, placed through the well casing or wall, shall be sealed.
- e. Dug wells shall not be subject to flooding.

4. *Naturally Flowing Wells*

- a. Flow shall be controlled.
- b. Permanent casing and grout, unless Schedule 40 or greater steel casing is used, shall be provided.
- c. If erosion of the confining bed appears likely, special protective construction may be required by the reviewing authority.

4.13.7 Well Pumps, Discharge Piping and Appurtenances

- 1. Low water shutoff switch shall be installed 5 feet above the top of the upper screen.
- 2. Foot valves shall be provided.
- 3. Line shaft pumps shall:

- a. Have the casing firmly connected to the pump structure or have the casing inserted into a recess extending at least 0.5 inch into the pump base, and
 - b. Have the pump foundation and base designed to prevent water from coming into contact with the joint.
4. Where a submersible pump is used:
- a. The top of the casing shall be effectively sealed against the entrance of water under all conditions of vibration or movement of conductors or cables, and
 - b. The electrical cable shall be firmly attached to the riser pipe at 20-foot intervals or less.
5. *Discharge Pipe*

The discharge pipe for each well shall:

- a. Be designed so that the friction loss will be low
- b. Have control valves and appurtenances located above the pumphouse floor when an above-ground discharge is provided
- c. Be protected against the entrance of contamination
- d. Be equipped with a check valve, shutoff valve, pressure gauge, means of measuring flow, and smooth nosed sampling tap located at a point where positive pressure is maintained and at least 100 feet distance from pumping station
- e. Where applicable, be equipped with an air release-vacuum relief valve located upstream from the check valve, with exhaust/relief piping terminating in the down-turned position at least 18 inches above the floor and covered with a 24-mesh corrosion resistant screen
- f. Be valved to permit test pumping and control of each well
- g. Have all exposed piping, valves, and appurtenances protected
- h. Be properly anchored to prevent movement
- i. Be protected against surge or water hammer
- j. The discharge piping shall be provided with a means of pumping to waste, such as a hydrant, but shall not be directly connected to a sewer.

6. *Pitless Well Units*

- a. The Department must be contacted for approval of specific applications of pitless units.
- b. Pitless units shall:
 - (1) Be threaded or welded to the well casing
 - (2) Be of watertight construction throughout
 - (3) Be of material and weight at least equivalent and compatible to the casing
 - (4) Have field connection to the lateral discharge from the pitless unit of threaded, flanged or mechanical joint connection,
 - (5) Terminate at least 18 inches above final ground elevation or 2 feet above the 100-year flood elevation or as the Department directs
- c. The design of the pitless unit shall provide:
 - (1) Access to disinfect the well
 - (2) A properly constructed casing vent
 - (3) Facilities to measure water levels in the well
 - (4) A cover at the upper terminal of the well that will prevent the entrance of contaminants
 - (5) A contamination-proof entrance connection for electrical cable
 - (6) An inside diameter as great as that of the well casing, up to and including casing diameters of 12 inches, to facilitate work and repair on the well, pump, or well screen

7. *Casing Vent*

Provisions shall be made for venting the well casing to the atmosphere. The vent shall terminate in a downturned position, at or above the top of the casing or pitless unit in a minimum one and 0.5 inch diameter opening covered with a 24-mesh, corrosion resistant screen. The pipe connecting the casing to the vent shall be of adequate size to provide rapid venting of the casing.

8. *Water Level Measurements*

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- a. Provisions shall be made for periodic measurements of water levels in the completed well.
- b. When recommended, installation of permanent water level measuring equipment shall be made using corrosion resistant materials attached firmly to the drop pipe or pump column and in such a manner as to prevent entrance of foreign materials.

4.13.8 Observation Wells

Observation wells shall be protected at the upper terminus to preclude entrance of foreign materials.

4.14 WELL ABANDONMENT AND DECOMMISSIONING

No supplier of water may abandon a source of water supply without the prior written approval of the Department. Submittal of the well abandonment application must be accompanied by the appropriate permit application (BRP WS 26) and fee, if applicable. The Department will not approve the abandonment of any public water supply unless the supplier of water demonstrates to the Department's satisfaction that such action will have no significant adverse impact upon the supplier of water's present and future ability to provide continuous, adequate service to consumers under routine and emergency operating conditions, including emergencies concerning the contamination of sources of supply, failure of the distribution system and shortage of supply.

The following process has been adapted from the well decommissioning section of the Standard References for Monitoring Wells, WSC-310-91, and modified where appropriate for the decommissioning of public water supply wells, wellfields, and observation wells.

A. Purpose

Any abandoned well that is no longer in use or that is unfit for its intended purpose should be decommissioned. Plugging the well and restoration of the surface are the central features of the decommissioning process. For small diameter wells, plugging consists of constructing a low permeability cylinder or plug within that portion of the subsurface occupied by the well. For most larger diameter wells, plugging consists of filling the majority of the well with a clean material and inserting a low permeability plug at the surface.

Surface restoration consists of the removal of the upper 3 or 4 feet of the well and backfilling the area with an effective seal.

Proper abandonment of wells will:

1. Eliminate physical hazards
2. Prevent ground water contamination
3. Conserve the yield and hydrostatic head of confined aquifers
4. Prevent the intermingling of potable and non-potable groundwater, and
5. Prevent the migration of contamination through a confining layer separating aquifers

It should be noted that the objective in Massachusetts differs markedly from the goals established by the American Water Works Association and the statutes, regulations, or guidelines of most other states. Many organizations advocate the concept of restoration, as far as possible, of the controlling hydrogeological conditions that existed before the well was drilled and constructed. To accomplish this goal some states have suggested the placement of sand and gravel opposite the more permeable subsurface zones and clay opposite less permeable zones. Ideally this represents the proper method of well abandonment, but in practice, this procedure may be very difficult to properly execute.

The Department therefore will require this method be used only for confined aquifer wells where the possibility of cross-contamination of aquifers can be significantly reduced by the placement of low permeability material opposite confining layers.

In order to meet the objectives of proper plugging as stated above, DEP has tried to develop a simple, workable approach that will solve the existing and potential problems from unsafe non-decommissioned wells.

Well decommissioning should be completed by a registered Massachusetts well driller or a person knowledgeable with the installation of wells. There is no nationally recognized or state-approved examination or certification process for well decommissioning and plugging. However, it is obvious that a well contractor or person who is familiar with well construction and the geologic conditions of their region is preferable to a person who does not routinely perform such work.

B. Clearing the Well

Decommissioning a well starts with removal of any obstructions, such as drop pipes, check valves and pumps, and clearing any obstacles or debris that may have entered the well.

When the well is obstructed by pumps or other equipment that have been dropped down the well, the debris must be removed or "fished" out before the well can be sealed. A variety of fishing tools are used to remove obstructions. Threaded taps on the end of a drill rod may be run into the hole in an attempt to screw into the top of a pump or drop pipe. Another type of equipment used is an 'over shot' (a casing

with inner teeth that is run over the obstacle to be removed). Corkscrews and spears also have been used to hook the obstacle for removal.

In some instances the driller may chop or grind up the obstacles in an attempt to clear the well. Debris or other materials such as rock, sand, clay, stones, and wood is usually drilled out or washed out of the hole. This technique appears to be suitable for destroying multi-level wells installed within a single borehole.

C. Plugging Material and Procedures

There are a large number of plugging materials available that can be used to plug abandoned wells. Each grout has certain special characteristics and distinctive properties. Therefore, one plugging material may be especially suited for doing a particular job. The selection of the most appropriate material or combination of materials is dependent on the construction of the well, the nature of the formation penetrated, the material and equipment available, the location of the well with respect to sources of contamination, and the cost of doing the work.

Recognizing that several well types exist in Massachusetts, DEP recommends plugging procedures for four general categories of wells:

1. *Sand and Gravel Wells with Diameters Greater than 2.5 Inches*

Because some of these wells could potentially have large diameter casing it generally is considered prohibitively expensive to completely fill them with sealing material. Sealing materials are watertight substances that prevent water and contaminants from entering and seeping through abandoned wells. The proper procedure for the decommissioning of these wells will be the following: the casing will be cut off 4 feet below the surface. Fill material (clean sand, gravel or pea gravel or crushed stone) will be used to fill the casing to within 10 feet of the top of the cut off casing. The upper 10 feet will be filled with a mixture of neat cement and 6% by weight bentonite. The plugging material should be allowed to flow out the top and along the sides of the casing to assure that a proper seal is established. The upper 4 feet of soil from the top of the casing to the surface should be properly compacted.

2. *Bedrock Wells with Diameters Greater than 2.5 Inches*

Bedrock well casings will be cut off 4 feet below the surface. To prevent the transport of fill material in fractures, it is recommended that larger diameter fill material, such as gravel or pea gravel, be used. The well will be filled to within 10 feet of the top of the cut off casing. The upper 10 feet of the casing will be filled with a mixture of neat cement and 6% by weight bentonite. The plugging material should be allowed to flow out and along the sides of the casing to assure that a proper seal is established. The upper 4 feet of soil from

the top of the casing to the surface should be properly compacted.

3. *Confined Aquifer Wells*

The low permeability layer that creates the confined aquifer must be sealed so that there is no chance of leakage between aquifers and the yield and hydrostatic head of the aquifer can be retained. A mixture of neat cement and 6% by weight bentonite will be used to seal the confining layer and will extend 10 feet below and 10 above the confining layer. Clean fill can be used to plug the remainder of the well in the confined and unconfined units. The well casing will be cut off 4 feet below ground surface and the top 10 feet of the casing will be filled with a mixture of neat cement and 6% by weight bentonite. The upper 4 feet of soil from the top of the cut off casing to the surface should be properly compacted.

4. *Small Diameter Wells (diameters less than or equal to 2.5 inches)*

For all small diameter wells (less than or equal to 2.5 inches), a mixture of neat cement and 6% by weight bentonite possesses most of the advantages that DEP looks for in a plug for wells where the grout will be inserted through the well riser. This neat cement mixture may be used as grout for wells installed in all geologic formations. This neat cement mixture is superior for sealing small openings, for penetrating any annular space outside of casings, and for filling voids in the surrounding formation. When applied under pressure, it is strongly favored for sealing wells under artesian pressure or those encountering more than one aquifer. Decommissioning of a tubular wellfield can be accomplished by pulling the casings and allowing the formation to collapse in the hole. The surface should then be properly compacted to prevent water collection.

Completion of the decommissioning process will be conducted in accordance with the procedure described in the Final Surface Completion section below.

D. Placement of Plugging Materials

Good planning is the first step in decommissioning any well. Professional well contractors start by carefully measuring the depth and diameter of the well to determine the amount of plugging material required. After clearing of the well bore, the well is ready for plugging. For wells requiring a grout slurry, the mixture must be placed from the bottom to the top and not from the top to the bottom. In other words, slurries cannot be poured from the land surface into the borehole, annular space, or well to be sealed. When grout is placed at the bottom of the space to be grouted and finally appears at the surface or top, the integrity of the plug is assured. Methods involving pouring grout from the surface into the annular space are not reliable because bridging may occur and the depth of grout descent cannot be easily verified. However, pouring grout through a tremie pipe is sometimes a

4.14 Well Abandonment and Decommissioning

satisfactory alternative to pumping through a tremie pipe. An improperly sealed well may be as much a threat to groundwater quality as an unsealed well.

The well contractor should calculate the volume of slurry that will be needed to grout the well. He should have enough mixed slurry ready for placement so that it will not be necessary to stop the grouting process in order to prepare more slurry. Due to borehole irregularities, it is advisable to have on hand 25 to 50% more slurry than the calculated volume.

The grout pipe (or tremie pipe) method, either with or without a grout pump, appears to be a method of grout placement that will achieve all the objectives of the well plugging program. A vigorous preventative maintenance program for mixing and pumping equipment, compressors, hoses and fittings, is essential. This includes adequate clean-up of equipment after each grout job. Failure of equipment in the field can result in: waste of grouting material, lost labor and equipment costs, property damage, contamination of the grout, and/or an unsuccessful or incomplete grout job.

To assure that a well is properly plugged and that there has been no bridging of the material, verification of calculations and measurements are made by the well contractor to determine whether the volume of material placed in the well equals or exceeds the volume of the casing or the hole that has been plugged and/or filled.

E. Final Surface Completion

A proper surface seal is the final step in decommissioning a well. The well casing shall be removed 4 feet below ground surface. Sealing material placed at the top of the well should extend several inches above and around the outside of the cut-off casing to reduce seepage down the outside of the casing. In some cases it may be necessary to bring in fill to properly complete the surface. Finally, compacted soil should be mounded over the well site. This is done to prevent water from collecting above the abandoned well.

F. Record of Decommissioning

Complete, accurate records of the entire decommissioning procedure should be submitted to the Department of Environmental Management, Division of Water Resources. The standard Well Completion Report form should be used, indicating the well is being decommissioned. A copy of the report should also be submitted to the water supplier and the town.